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MONTANA
STATE HIGHWAY COMMISSION

CONSTRUCTION MANUAL

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LEWIS M. CHITTIM
STATE HIGHWAY ENGINEER

IN REPLY REFER TO:

FOREWARD

This Construction Manual is intended to supplement the specifications and special provisions by providing guidance and information to aid the judgment of personnel responsible for the various phases of administering and inspecting road construction. Wherever a conflict exists between the specifications and instructions in this Manual, the specifications will govern. The Manual is not part of any contract so its instructions are not binding on the contractor.

We intend that procedures for administering the construction contract and inspecting construction will become standardized in each of the Divisions throughout the State. We also realize that instructions in the Manual will not cover every problem encountered and urge each engineer to use other reference material to stay abreast of modern construction methods and advancing technology. The Manual is not intended to stifle an employees initiative, instead it sets guidelines so that an employees initiative may be recognized and properly directed.

Employees to whom manuals are assigned are responsible for their care and are also expected to share the information with fellow employees who do not have manuals. Errors and omissions will be corrected by issuing revisions and new sections from time to time which are to be inserted by manual holders. Manuals are State property and are to be returned to the Department or Division head when an employee leaves the service of the Highway Commission. The cost of manuals that are lost or not returned or have become unusable will be deducted from an employees pay.

Much of the knowledge available in Construction Manuals from other states and the "know how" in the minds of our engineers has been used to compile this Manual and we are indebted to these many sources for their assistance.

Lewis M Chittim

Lewis M. Chittim, P.E.
State Highway Engineer

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WHAT'S THIS !! TWENTY YEARS OF PAPER WRAPPED UP IN ONE BOOK?
CONST. MANUAL

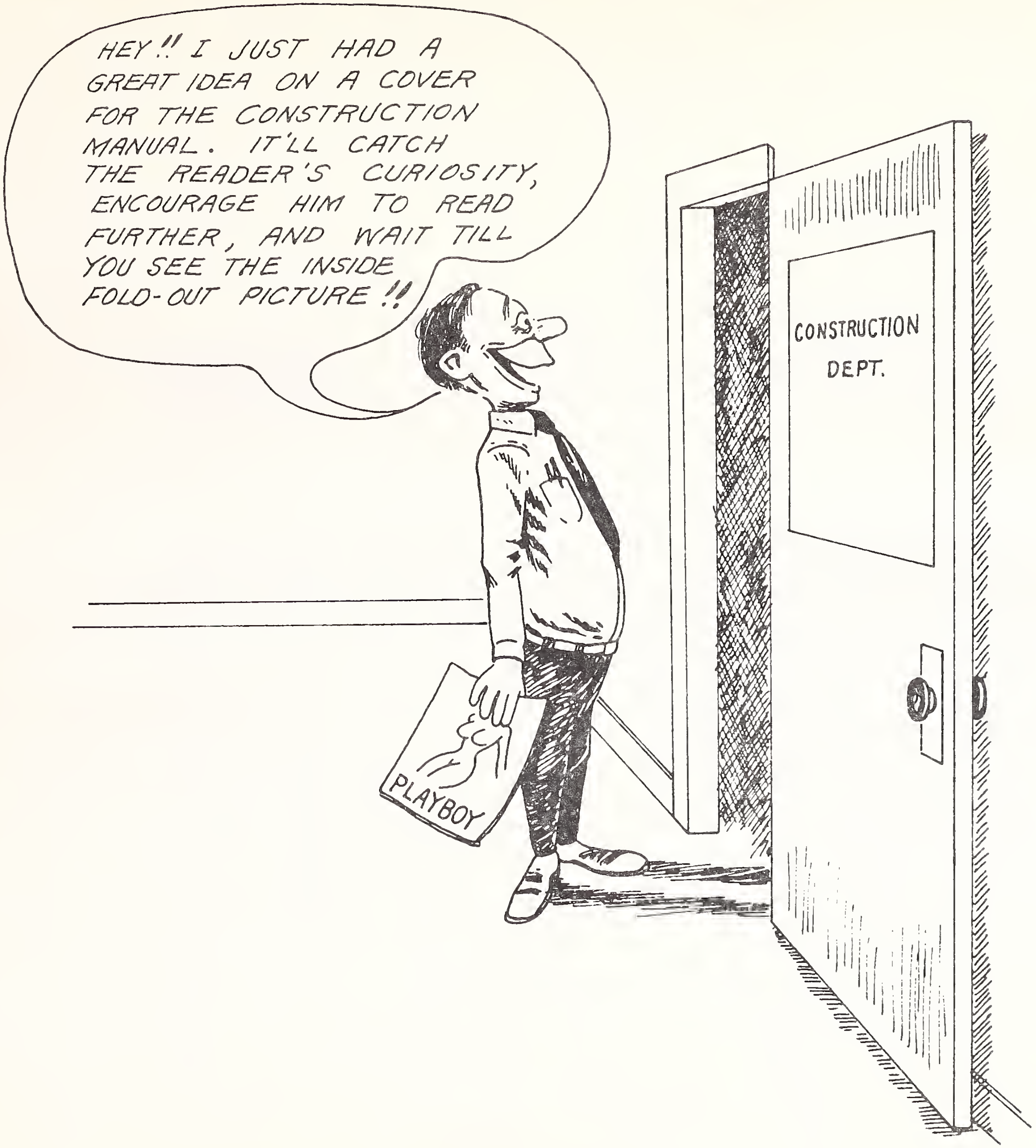

HEY!! I JUST HAD A GREAT IDEA ON A COVER FOR THE CONSTRUCTION MANUAL. IT'LL CATCH THE READER'S CURIOSITY, ENCOURAGE HIM TO READ FURTHER, AND WAIT TILL YOU SEE THE INSIDE FOLD-OUT PICTURE!!
CONSTRUCTION DEPT.
PLAYBOY

TABLE OF CONTENTS

CONSTRUCTION MANUAL

CHAPTER	SECTION	
I		GENERAL
	I-01	Introduction
	I-02	General Organization
	I-03	Public Relations
	I-04	Communications
	I-05	Project Management
II		CONTRACT ADMINISTRATION
	II-10	Definitions and Terms
	II-11	Scope of Work
	II-12	Control of Work
	II-13	Control of Materials
	II-14	Legal Relations and Responsibility
	II-15	Prosecution and Progress
	II-16	Measurement and Payment
	II-17	Contract Changes
	II-18	Contractor and Highway Department Relations
	II-19	Construction Forms, Records, Reports
	II-20	Utilities
	II-21	Reclamation of Gravel Pits and Borrow Areas
III		CONSTRUCTION SURVEYS
	III-30	General
	III-31	Construction Surveys for Roadway
	III-32	Construction Surveys for Small Drainage Facilities
	III-33	Construction Surveys for Miscellaneous Items
	III-35	Construction Surveys for Bridges
IV		CONSTRUCTION DETAILS
	IV-40	Clearance of Right-of-Way
	IV-41	Excavation and Embankment
	IV-42	Overhaul and Haul
	IV-43	Watering
	IV-44	Roadside Development
	IV-45	Aggregate Production and Surfacing
	IV-46	Cement Treated Base

TABLE OF CONTENTS

CONSTRUCTION MANUAL

IV CONSTRUCTION DETAILS (con't)

IV-47 Asphalt Concrete Pavement
IV-49 Road Mixed Asphalt Surfacing
IV-50 Seal Coats
IV-51 Portland Cement Concrete Pavement
IV-52 Reinforcing Steel
IV-55 Excavation for Culverts and Minor Structures
IV-56 Inspection and Installation of Culverts
IV-57 Inspection and Installation of Corrugated Metal Pipe
IV-58 Inspection and Installation of Reinforced Concrete Pipe
IV-59 Inspection and Installation of Structural Plate Pipe Culverts and Stockpasses
IV-60 Inspection and Installation of Pipe Underdrains
IV-61 Remove and Relay Culverts
IV-62 Miscellaneous Rigid Pipe
IV-63 Curb and Gutters
IV-64 Fence
IV-69 Markers and Monuments
IV-70 Traffic Control
IV-74 Pneumatically Applied Mortar
IV-75 Temporary Erosion and Sedimentation Control

TABLE OF CONTENTS

CONSTRUCTION MANUAL

CHAPTER	SECTION	
V		APPENDIX
	V-1	Areas of Circular Segments
	V-2	Lengths of Circular Arcs for Unit Radius
	V-3	Aggregate Spreads
	V-4	Linear Feet of Spread for Liquid Asphalt
	V-5	Capacity Chart for Cylindrical Tanks
	V-6	Skew Areas of CMP
	V-7	Skew Areas of RCP
	V-8	Theoretical Surface Ditch End Areas for 2% Slope Change
	V-9	Standard Slope Rounding End Areas for 5% Slope Change
	V-10	Conversion of Minutes and Seconds to Decimal Parts of a Degree

Rev. 5-1-73

CONSTRUCTION MANUAL

CHAPTER I

GENERAL

I-01 INTRODUCTION

- 01.01 Purpose
- 01.02 Chapter Numbering and References
- 01.03 Revisions and Updating

I-02 GENERAL ORGANIZATION

- 02.01 Organization Chart
- 02.02 Headquarters Organization-Related to Construction
- 02.03 Division Construction Section

I-03 PUBLIC RELATIONS

- 03.01 General
- 03.02 Relations with the General Public
- 03.03 Relations with Property Owners
- 03.04 Relations with Other Governmental Agencies
- 03.05 Relations with Utility and Railroad Companies
- 03.06 Relations with the Contractor

I-04 COMMUNICATIONS

- 04.01 General Correspondence
- 04.02 Signatures on Claims and Correspondence
- 04.03 Telephone and Teletype
- 04.04 Radio

I-05 PROJECT MANAGEMENT

- 05.01 Personnel
- 05.02 Project Files
- 05.03 Quantity Documentation
- 05.04 Project Diary
- 05.05 Project Offices and Field Laboratory
- 05.06 Internal and Interdepartmental Relations
- 05.07 Employees Conduct
- 05.08 Construction Engineering Costs

I-01 Introduction

01.01 Purpose

This Construction Manual describes the duties and responsibilities of field engineering personnel assigned to highway construction projects. It includes construction requirements, procedures, information and practices to be followed in the supervision and inspection of highway construction work. Our construction engineering employees are expected to study it carefully and become thoroughly familiar with its contents, in addition to the requirements of the Specifications. This will promote better knowledge of the construction operations, proper inspection of the work and the uniform application and interpretation of the specification requirements.

This manual is not a contract document. It is not intended to be. Rather, it is a guide book of reference and instruction for use in understanding and interpreting the contract documents. The Construction Manual is also intended to aid in constructing the project and administering the construction contract. The ideas and material used to write this manual have been taken from many sources but are generally based on intention indicated in the plans and specifications. Time-proven construction practices developed over the years by the construction industry and our engineering staff have also been incorporated into the manual. Construction field and office personnel should follow the directions and be guided by the instructions contained in this manual. However, if statements are encountered that are contrary to the specification intention, the specifications will prevail over the construction manual.

01.02 Chapter Numbering and References

The manual contains four chapters and an appendix. Within each chapter are sections that begin with two numbers. The first number is the chapter number and the second number is the section number of that chapter (the Introduction is Section 01 of Chapter I). Each page of the manual is numbered with the section number then the page number,for instance, the 1st page of the Introduction is numbered 01-1, the second page 01-2, etc.

Where a section of the manual does have a counterpart in the book of Standard Specifications, it is given a corresponding title. For instance, "Scope of Work" can be found in both the manual and the Standard Specifications.

Each section of the manual begins with references to the Standard Specifications, to other sections of the construction manual and to other Highway Commission manuals. All publications referred to are the latest edition unless a particular edition is cited. A reference within a section pertains to other sections of the manual unless otherwise described.

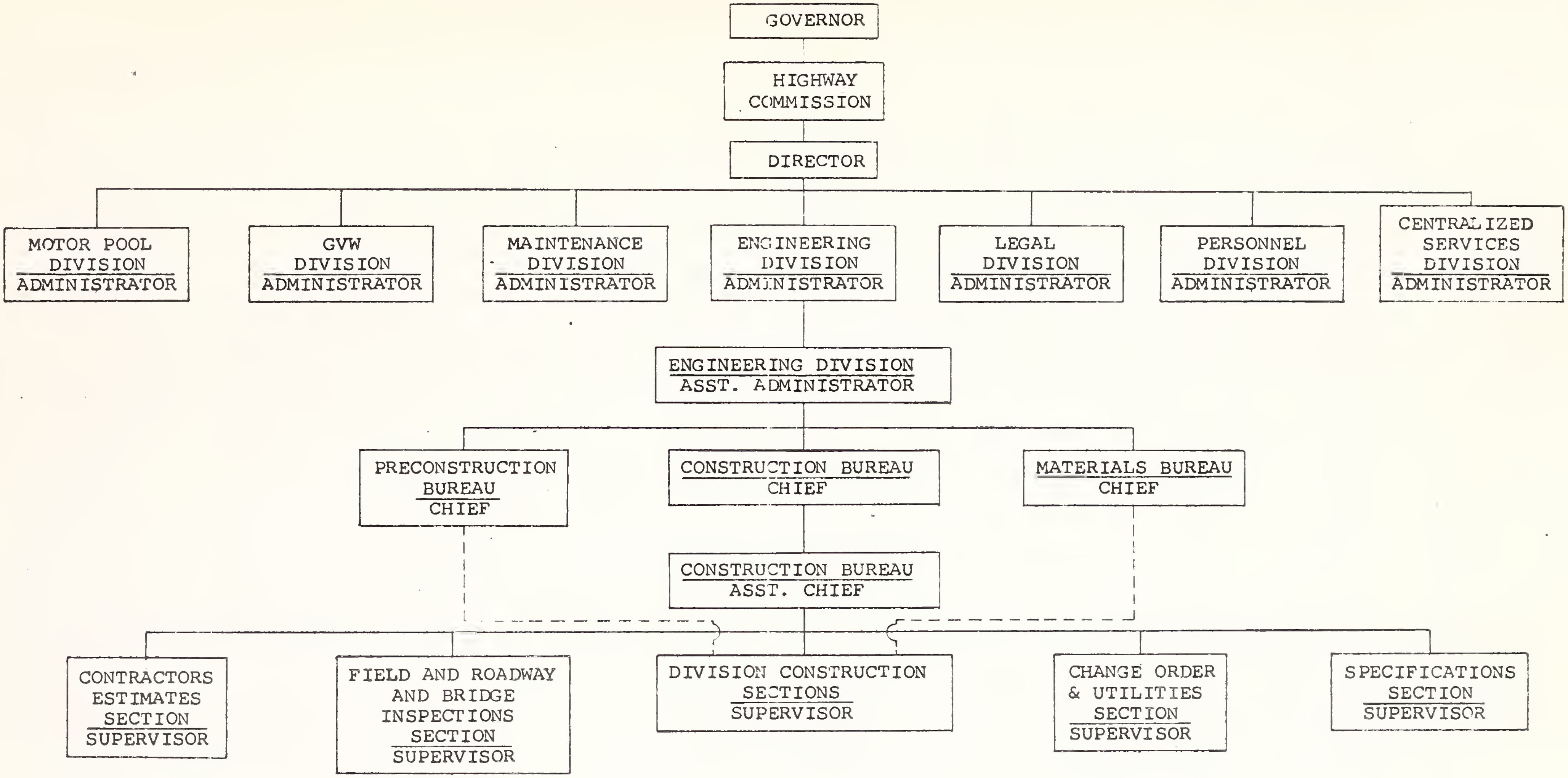
01.03 Revisions and Up-Dating

The salient features of policy and procedure established by construction memoranda issued between January 1957 and August 1967 have generally been incorporated into this manual under each applicable section. However, none of these memoranda are superceded by the Construction Manual unless specific statements to that effect have been made in the Manual or in construction memoranda.

Each manual is given a number and is to be kept up-to-date by the Division Office Engineer by incorporating revisions in all manuals in that Division (or seeing that this is done) from time to time when revisions are received. Revised sections will be submitted at least on a yearly basis in December of each year. Various construction memoranda issued throughout the year will be included in the proper section of the manual by revising the applicable sections.

Any suggestions for improvement, additions ,or corrections to the manual or requests for additional copies or revised pages should be directed to:

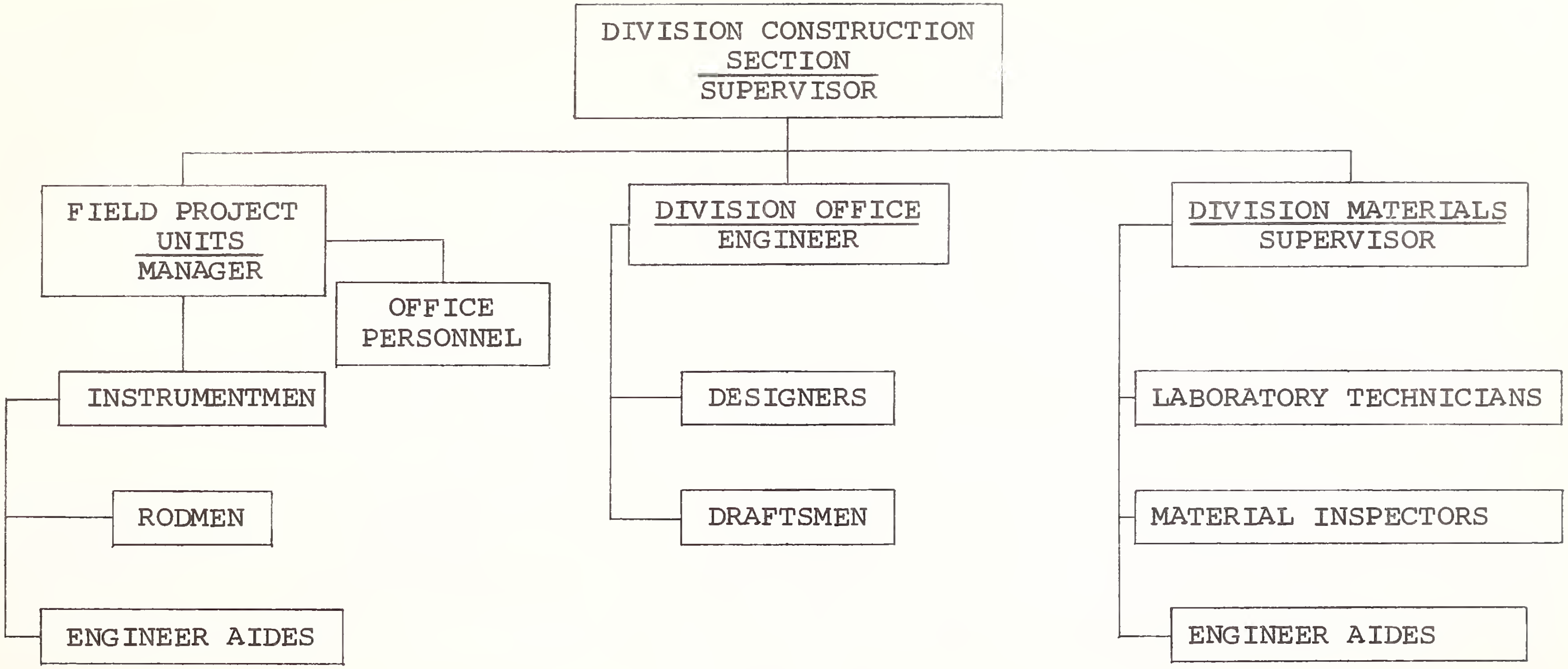
Construction Engineer
Montana Highway Commission
Helena, Montana 59601


GOVERNOR
HIGHWAY COMMISSION
DIRECTOR
MOTOR POOL DIVISION ADMINISTRATOR
GVW DIVISION ADMINISTRATOR
MAINTENANCE DIVISION ADMINISTRATOR
ENGINEERING DIVISION ADMINISTRATOR
LEGAL DIVISION ADMINISTRATOR
PERSONNEL DIVISION ADMINISTRATOR
CENTRALIZED SERVICES DIVISION ADMINISTRATOR
ENGINEERING DIVISION ASST. ADMINISTRATOR
PRECONSTRUCTION BUREAU CHIEF
CONSTRUCTION BUREAU CHIEF
MATERIALS BUREAU CHIEF
CONSTRUCTION BUREAU ASST. CHIEF
CONTRACTORS ESTIMATES SECTION SUPERVISOR
FIELD AND ROADWAY AND BRIDGE INSPECTIONS SECTION SUPERVISOR
DIVISION CONSTRUCTION SECTIONS SUPERVISOR
CHANGE ORDER & UTILITIES SECTION SUPERVISOR
SPECIFICATIONS SECTION SUPERVISOR

02.01 - Simplified organization chart - related to construction - headquarters level

Administrative ____________

Functional------------------



02.01 Organization Chart - Related to Construction - Division Level

I-02 GENERAL ORGANIZATION

02.01 Organization Chart - Related to Construction

02.02 Headquarters Organization - Related to Construction

Director of Highways

The Highway Commission is directly represented by the Director of Highways who is the Chief Executive acting under the broad policy lines established by the Commission. A major portion of his activities and functions are necessarily accomplished and administered through delegation of authority to responsible, qualified subordinates.

Administrator - Engineering Division

The line of authority for field operations is directed from the Division Construction Sections through the Construction Bureau into the Engineering Division and then to the Director of Highways. This line of authority will aid communication and action by providing headquarters and field personnel with more co-ordination of Preconstruction, Construction, and Materials problems by collecting these functions under one head.

The Administrator in charge of the Engineering Division directs the Preconstruction, Construction, and Materials Bureaus. In matters related to Construction, he is responsible for administering the total construction program and coordinating construction programs with other highway administrative offices. He performs liaison with the Federal Highway Administration and other Federal or State Agencies.

Chief - Construction Bureau

The Construction Bureau Chief is authorized to take appropriate action on contract changes, time extensions, liquidated damages, contractors claims, progress and final estimates, Federal Highway Administration inspection recommendations, labor compliance matters and other construction activities delegated to him by the Engineering Division Administrator. He works with the Division Construction Section Supervisors and others in providing supervision and control of all construction projects to assure quality construction, conformance to contract requirements and to resolve construction problems.

Construction Bureau

The Construction Bureau is staffed by various engineering personnel who make frequent field inspection trips to audit records, check specification compliance and inspect construction progress. This staff gives advice on problems that may arise, checks on inspection and testing practices in use and helps promote practical uniformity in contract administration at the field level.

Differences of opinion between the Construction Bureau staff and field personnel may occasionally arise over field procedures or methods used to solve field problems. When such differences do occur, it is the intention of the Construction Bureau personnel to discuss the difficulty, on the job, with the Project Manager and arrive at a practical solution. If an unusual situation demands immediate attention and urgent changes are needed, these changes are to be made immediately with responsibility for the change resting with the Construction Bureau. However, in a normal situation, the changes recommended by the Construction Bureau will be referred through regular channels (Construction Bureau Chief and Division Construction Section Supervisor and Project Manager) for discussion and appropriate action.

Written reports carrying recommendations or commendations are submitted to the Construction Bureau Chief by members of his staff after their field inspection trips. Copies of these reports will be submitted, as needed, to the Division Construction Section Supervisors for distribution to their appropriate personnel. These recommendations are to be given early attention with a serious effort made for their implementation, thus overriding many of the deficiencies cited in Federal Highway Administration inspection reports.

02.03 Division Construction Section

Supervisor Division Construction Section

The Division Construction Section Supervisor is the authorized representative of the Construction Bureau Chief in all construction matters for the geographical area to which he is assigned. He accomplishes all phases of this assignment with the help of his staff but is free to call on headquarters specialists for assistance in solving the more unusual or complicated problems he encounters. His responsibilities and duties include scheduling construction surveys, coordinating personnel assignments, providing for inspection of materials and workmanship, assuring that plans and specifications are being complied with and arranging other numerous activities of contract and administration. Project Managers are directly responsible to the Division Construction Section Supervisor (refer to Section I-05 for detailed information on duties and responsibilities).

Division Office Engineer

Division Office Engineers report directly to the Division Construction Section Supervisor for direction of their work. These engineers perform various construction functions such as thorough checking of final estimates and supporting data, review contract changes, perform routine correspondence and distribution thereof, supervise design crews, present testimony at condemnation hearings, review field changes and drainage problems, conduct or attend preconstruction conferences and perform overall liaison between the Division Construction Section Office and project functions under the authority of the Division Construction Section Supervisor.

Division Materials Section

Division Materials Supervisors are under the direct supervision of the Division Construction Section Supervisor but derive the majority of their guidance and direction from the Materials Bureau Chief, Helena. Personnel working in the division materials section are responsible for training construction personnel in testing, sampling, and inspection methods as well as performing the numerous testing and inspection functions assigned to them. (Refer to the various materials memoranda, chapter 4 and the test methods manual.)

I-03 PUBLIC RELATIONS

03.01 General

An inspector's work can be the deciding factor between an excellent job and an average or poor job. The inspector's conduct with the property owners, contractors and utilities, etc., will help or hinder him in making his inspections and in obtaining a satisfactory completed project. His relationship with these other agencies or individuals should be spiced with courtesy, firmness and honesty.

The subject of public relations is discussed in five categories: relations with the general public, relations with property owners, relations with other government agencies, relations with utility and railroad companies, and relations with the contractor.

The engineer should always keep in mind that he is a representative of the Montana Department of Highways and the State of Montana. As such he is expected to conduct himself in a manner that will command respect and be a credit to the organization and State.

03.02 Relations with the General Public

A. Communications Media

Where information must be conveyed to a very large number of highway users full use of the press, radio, or even television can be advantageous. Any news releases must be cleared through channels and the Public Information Office.

The Division Construction Supervisor may desire to contact the local press before the job starts, tell them how they can get authentic information during the life of the contract and invite them to tour the job with the Project Manager.

Project Managers are urged to cultivate a relationship of mutual understanding with all representatives of the public, including members of the press. It is proper for a Project Manager to show the local newspaper editor over a proposed project, in the same manner as he shows the job to prospective contractors. The local newspaper may be interested in running articles when the job is started, partially completed and when it is completed. Information affecting the traveling public, such as, the temporary routing of traffic on detours, is of special interest to newspapers. In special cases, pamphlets may be prepared and passed out to motorists who are subjected to delays in passing through construction. The Public Information Office has personnel trained in radio, TV, magazine and newpaper work and they are anxious to have information on news items of general interest for the release to magazines and newspapers. Any new unique feature being employed in the work of the contractor or by the survey crew may be transmitted to the Public Information Office for consideration.

If points of conflict are observed which might develop into public controversies and misunderstandings, this information should be transferred through channels so that early news releases can inform the public of the facts. It is important that information given to the public not be slanted or be evasive. However, highway employees are strongly cautioned not to divulge any information to the traveling public or other persons that is not their concern. Be courteous, help the motorist through the project by giving directions for other highway routes, miles between towns, etc. All other requests are to be referred to the Division Construction Supervisor.

B. Public Records

It is proper for custodians of records in the Department of Highways to allow the following public records to be inspected without question after the proper highway officials have been made aware of the request.

1. Minutes of the Highway Commission meetings.
2. All resolutions adopted by the Department of Highways.
3. All contracts signed by the Department of Highways.
4. All agreements signed by the Department of Highways.
5. All surveys adopted by the Department of Highways.
6. Generally anything signed by the Department of Highways in its public capacity.
7. Approved maps of highway locations.

It is proper to devulge general information of a nature that will be of help and assistance to people as we have in the past, but any matters which may be used in contemplated or pending litigation, such as, appraisals of property, reports of damage to real or personal property, results of core drills, reports of Highway employees made to their superiors relative to Highway business, proposed highway routings, or the opinion of any expert whether employed by the Department of Highways or not should not be divulged. However, if there is question as to whether the divulging of the information may be detrimental to the Department of Highways, such requests or a notification of such request should be forwarded through channels to the Legal Department.

All documents in our files can be impounded by the court. The only documents that cannot be introduced in evidence by the opposition are so called investigation reports, and these must be labeled that they are compiled for use only in a legal action. All reports covering controversial subjects should be kept completely factual throughout and not contain opinions.

In public relations work, the importance of starting early and keeping it up should be stressed. Past experience has proven the value of personal public contact by the Project Manager and if possible the contractor's representative. These individuals may call on property owners before the work of construction starts, briefly outlining the work to be done that will affect that owner and assuring the property owner that inconvenience and nuisance will be held to a minimum. There are good ways to promote the dissemination of project information to the general public. The appearance of the Division Construction Supervisor or members of his staff as speakers at meetings of the local Chamber of Commerce or service clubs is a very good method of providing information to the general public. Appearances of this kind should be cleared with the Public Information Office. Project Managers who are inclined to join local service organizations may do so. Through their contacts with other club members, they can help to promote a good image of the Department of Highways throughout the State.

03.03 Relations with the Property Owners

Property owners adjacent to the construction operation are the individuals who are most directly affected by the construction progress, and they constitute one of the more important phases of the engineer's public relation work. The Project Manager is urged to conduct himself in the same courteous manner as he would expect to be treated by others. Patient listening to the property owner's problem, request or questions, and taking time to answer him or explain, can generate a feeling that the Department of Highways is not an impersonal organization running rough-shod over the general public or the individual. This will generally help to avoid unreasonable demands and compliants by the property owner. The Project Manager should in the course of his initial contact with property owners convey such information as his address and his telephone number, where his office is located and how long the property owner may be inconvenienced. The first initial contact with various property owners takes time but paves the way for obtaining future construction permits, and other right-of-way negotiations. The initial contact may also help to prevent future law suits between property owners and the State of Montana.

Rigid control of access to Interstate highways is primarily in the interest of safety to the motorist, but the general public, especially those persons living along the right-of-way, are usually not aware of these safety features. Time spent in explaining the benefits of access control may greatly improve the relationship with these people.

No efforts should be spared to reduce traffic inconveniences to a practical minimum. Requests for legitimate information should always be answered in a frank and truthful manner, keeping in mind that after the pertinent policy has been determined, there is no valid reason to withhold known facts from persons entitled to them. An indecisive, evasive or ambiguous answer is most disconcerting to an individual or civic organization sincerely seeking legitimate information. If equivocation is evident it tends to undermine confidence in the Department of Highways.

03.04 Relations With Other Governmental Agencies

A. Relations with the Federal Government and Other State Agencies

Construction work on contracts, financed in whole or in part with federal funds, will be subject to inspection by the Federal Highway Administration engineers. These engineers also approve the expenditure of federal funds on the total project upon final completion. The Project Manager shall cooperate with representatives of the FHWA by giving such assistance as is required or requested in making inspections, in securing approval of the work, in discussing extra work, change order work, supplemental agreements, as well as discussing contractor-engineer relations, or other matters that apply to that project.

The FHWA is not actually a party to the contract between the contractor and the State of Montana. However, their control of federal funds puts them in the commanding position to inspect and approve the completed highway work. Project Managers should deal with FHWA engineers in a courteous manner.

During construction work, the Project Manager shall see that the contractor complies with all federal and state forest rules and regulations regarding the protection of forests within the boundaries of the national or state forests. The contractor shall take all reasonable precautions to prevent and suppress forest fires. The engineer shall report to the nearest forest fire warden at the earliest time possible the location and extent of any fire seen by him. He shall take immediate steps to control the fire, if controllable within his practical abilities.

Construction work that occurs in the vicinity of rivers and streams may require inspection and approval of the State Fish and Game Department. Prior contact with the individuals of this agency is essential where fish ladders, ponds, large rocks, and other stream controls for the conservation of fish and wildlife is desired or required.

Sometimes communication problems develop in the field between State and contractor personnel regarding matters of interest to the Department of Fish and Game.

Construction activities are reviewed at the preconstruction conference between us, the contractor and the Department of Fish and Game people and general agreement is reached. It is assumed that actual construction will be done according to this agreement.

However, when actual construction starts, it seems the contractor doesn't tell his superintendent, his foreman and other workers just what is expected of them and of the work. State people are inclined to think it is a Fish and Game problem so maintain a hands off attitude. Now the Fish and Game people, having heard the contractor and state agree to do the work, think the work will go according to the plan discussed. Since they are a third party, they can't direct the operations and naturally leave the work up to the contractor and engineer. Consequently, if nothing is done or if what is done is not done as agreed it isn't the fault of the Fish and Game people.

Please take the necessary steps to be sure the man or men doing the work know what is to be done in the way of stream protection.

B. Relations with Counties and Cities

On projects which are financed jointly by the FHWA and a county or city, there will have been an agreement executed between the FHWA and the county or city involved, in which both parties agree that the Department of Highways shall act as the agent of the county or city. The parties to the contract are therefore, the same as on regular federal aid work, namely, the Department of Highways and the contractor.

Since the county or city has a financial interest in the project, the representatives of the county or city shall be accorded every courtesy in inspecting the work and giving counsel to the Project Manager; however, the Project Manager is not obligated to accept or execute any suggestions given. Every effort is to be made by the Project Manager to resolve any disagreement between himself and representatives of the local government. Local government and representatives can be shown the project during the initial and final phases of construction and problems affecting their organization discussed.

03.05 Relations with Utility Companies and Railroad Companies

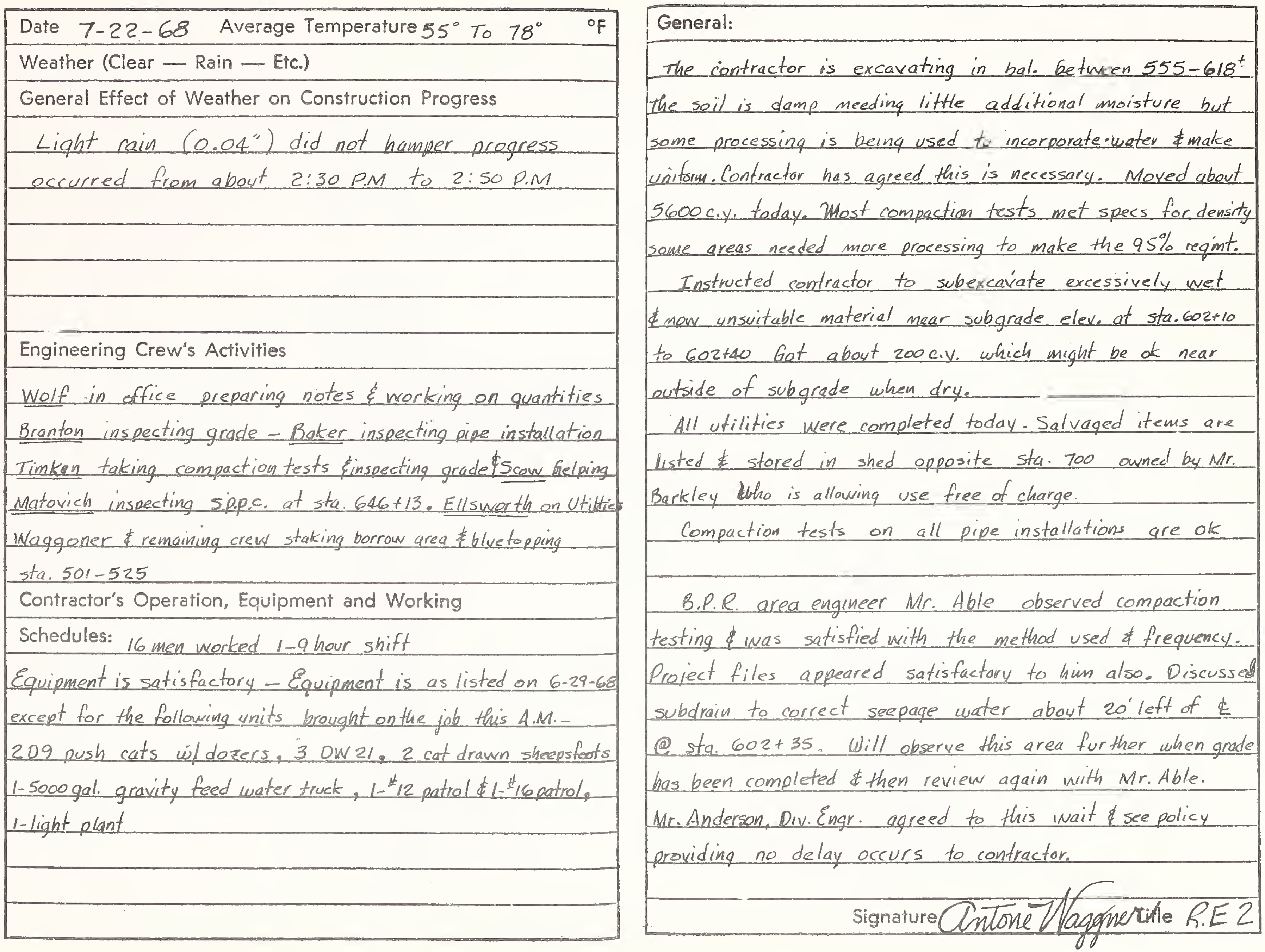
The Project Manager should assure himself that all prior authorizations and agreements have been ccompleted and executed between the Department of Highways and the utility company prior to the start of any work to be done by the utility company. A separate construction conference dealing with the Department of Highways and the utility company should be conducted. A report of this conference should be sent to the Division Construction Supervisor and to the Construction Bureau of Helena. The expected starting date, schedule of the work, where salvage material is to be stored, the name of the representative of the utility company who is to be in charge of the work should all be conveyed.

Federal reimbursement for work done by the railroad company is subject to the provisions of the FHWA Policy and Procedure Memorandum 30-3. The various agreements executed between the Department of Highways and the railroad companies must be gone over quite thoroughly by the Project Manager. Any questions that the Project Manager may have should be discussed with the representative of the railroad company prior to starting the work and any questions that arise should be immediately referred to the Division Construction Supervisor for action. Oftentimes the specifications under which the railroad company desires the relocation work to be done may be different than the usual practice of the Department of Highways. Therefore, a good public relations with the Department of Highways and the railroad company representative is imperative.

03.06 Relations With the Contractor

The Project Manager in his dealings with the contractor and the contractor's personnel should make his position absolutely clear from the start of the project. He should discuss the various work schedules, equipment to be used, and general method of operation. The contract is to be administered in accordance with the plans and specifications and it is far better to let the contractor know the intention of the Project Manager right at the start of the project than allow a poor situation to exist and then attempt corrective measures later on. The representative of the contractor who will be issuing instructions, acting as superintendent for the contractor, must be made known in writing to the Project Manager at the start of the work. All correspondence, discussions, and controversies should be directed through this superintendent rather than through any of the other individuals working with the contractor who have not been fully authorized to execute decisions made by the Project Manager or his staff. The employees of the Department of Highways who are assigned to the construction project must be thoroughly familiar with the plans and specifications governing the contractor. Clear evidence of a good solid possession of construction knowledge will go a long way in promoting smooth relations with the contractor's superintendent and foreman. If the Project Manager and his staff know the plans and specifications thoroughly the contractor's personnel will respect the engineer's judgment in all matters of controversy and any decisions that must necessarily be made. Differences of opinion between the Project Manager the contractor are not unusual. Where these differences of opinion do occur, the Project Manager should act with all courtesy but be firm in his opinion. If a controversy cannot be adequately decided on the project, the Project Manager should refer his opinions to the Division Construction Supervisor where further action can be taken. In all instances where controversy does exist, an attempt should be made to resolve such differences promptly and fairly with full consideration given to the terms of the contract and the intention of the specifications. The Division Construction Supervisor should be kept fully advised of all pertinent details regarding discussions between the engineer and the contractor. Appropriate notes should be made in the diary. Good relations developed between the Project Manager and the contractor's superintendent will ultimately result in a very satisfactory relationship between the Department of Highways and the contractor. These good relations can preclude many of the hard feelings, possible claims or possible law suits that may result due to personal animosity between the Project Manager and a contractor's superintendent.

The acceptance by the engineer or any of his assistants of gifts of any type, or gratuities in any form whatsoever, any loan of any value, or employment on a full or part-time basis will not be tolerated. The contractor shall not arrange for the purchasing or leasing of equipment, supplies or materials through or for any Highway employee.



Date 7-22-68 Average Temperature 55° To 78° °F

Weather (Clear — Rain — Etc.)

General Effect of Weather on Construction Progress

Light rain (0.04") did not hamper progress occurred from about 2:30 P.M to 2:50 P.M

Engineering Crew's Activities

Wolf in office preparing notes & working on quantities

Branton inspecting grade – Baker inspecting pipe installation

Timken taking compaction tests & inspecting grade & Scow helping

Matovich inspecting s.p.p.c. at sta. 646+13. Ellsworth on Utilities

Waggoner & remaining crew staking borrow area & bluetopping sta. 501–525

Contractor's Operation, Equipment and Working

Schedules: 16 men worked 1–9 hour shift

Equipment is satisfactory – Equipment is as listed on 6-29-68 except for the following units brought on the job this A.M.– 2 D9 push cats w/ dozers, 3 DW 21, 2 cat drawn sheepsfoots 1-5000 gal. gravity feed water truck, 1-#12 patrol & 1-#16 patrol, 1-light plant

General:

The contractor is excavating in bal. between 555–618± the soil is damp needing little additional moisture but some processing is being used to incorporate water & make uniform. Contractor has agreed this is necessary. Moved about 5600 c.y. today. Most compaction tests met specs for density some areas needed more processing to make the 95% reqmt.

Instructed contractor to subexcavate excessively wet & now unsuitable material near subgrade elev. at sta. 602+10 to 602+40 Got about 200 c.y. which might be ok near outside of subgrade when dry.

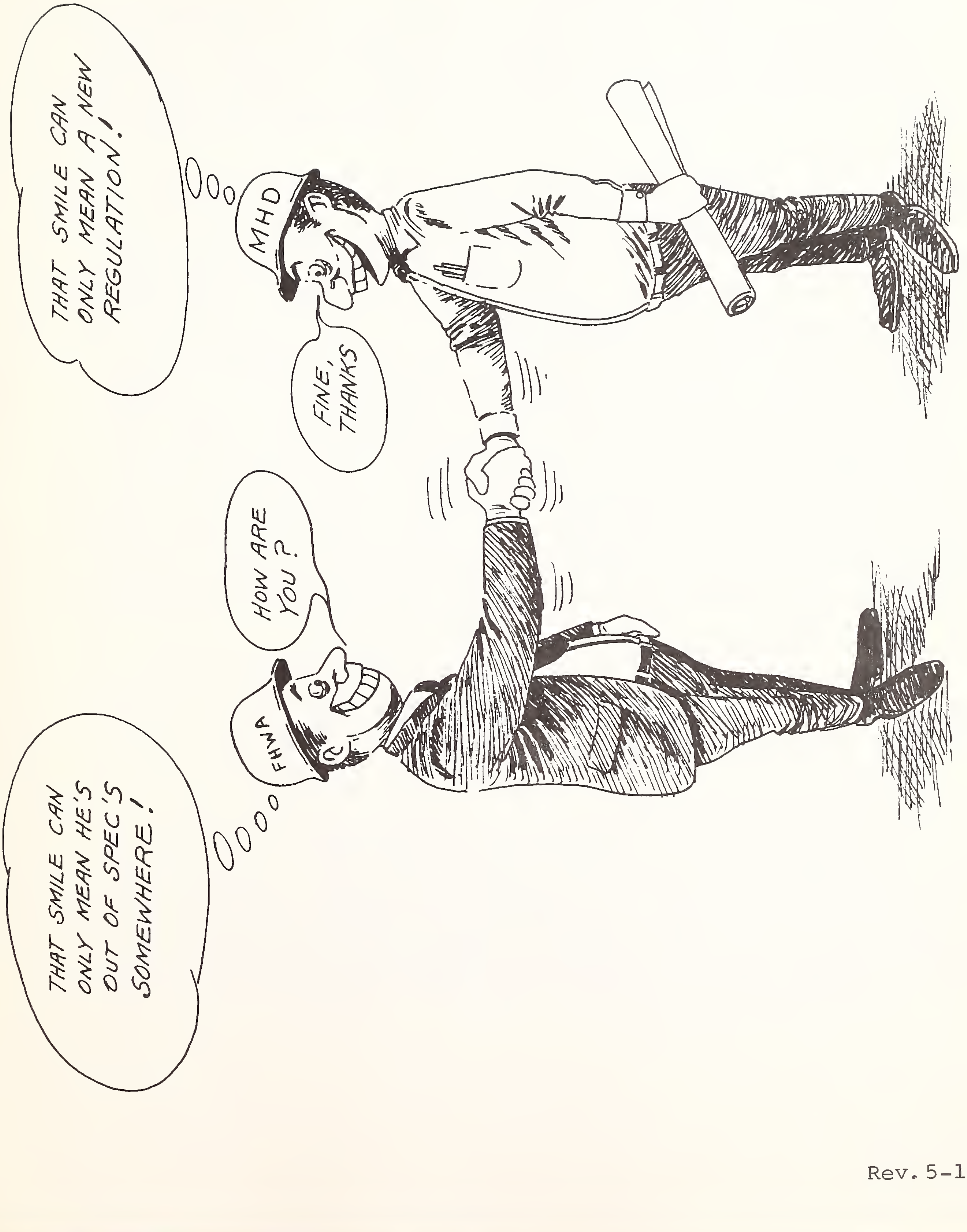
All utilities were completed today. Salvaged items are listed & stored in shed opposite sta. 700 owned by Mr. Barkley who is allowing use free of charge.

Compaction tests on all pipe installations are ok

B.P.R. area engineer Mr. Able observed compaction testing & was satisfied with the method used & frequency. Project files appeared satisfactory to him also. Discussed subdrain to correct seepage water about 20' left of ℄ @ sta. 602+35. Will observe this area further when grade has been completed & then review again with Mr. Able. Mr. Anderson, Div. Engr. agreed to this wait & see policy providing no delay occurs to contractor.

Signature Antone Waggoner Title R.E 2

FIG. I-3


THAT SMILE CAN ONLY MEAN HE'S OUT OF SPEC'S SOMEWHERE!
FHWA
HOW ARE YOU?
FINE, THANKS
MHD
THAT SMILE CAN ONLY MEAN A NEW REGULATION!

I-04 COMMUNICATIONS

04.01 General Correspondence

Directives, desirable goals, needed changes and similar information originates in the Construction Bureau or arrives in that office from the Director of Highways, other headquarter offices, from the field and other sources. This information is then molded into statements of policy and procedure for field use and for others who need it and distributed in the form of construction memorandums.

Construction memorandums contain information, clarification of specifications, directions on work, explanations on new policy, and various other matters of statewide importance which will later be combined and incorporated into the Construction Manual. Much thought and consideration has gone into the makeup of these memorandums, and the instructions are to be observed. However, should discrepancies or errors occur, these errors should be called to the attention of the Division Construction Supervisor, who in turn will contact the Construction Bureau. Should the instructions require correction, the Construction Bureau will issue new directions concerning the particular memorandum involved. Occasionally, in the past, memorandums of importance to the Project Manager have not been distributed to him. Any correspondence issued from the Construction Bureau and meant for distribution to the Project Manager shall always be distributed to the Project Manager by the Division Office. No exceptions are to be allowed. Should the Division Construction Supervisor be opposed to or not understand the information contained in the construction memorandum he should contact the Construction Bureau and obtain clarification, and then submit this construction memorandum to the proper persons involved.

Instructions, not contained in construction memorandums, that are needed by an employee to properly perform his duties should be issued to that employee either through his immediate supervisor or with his knowledge. The instructions should be sufficiently detailed so that the employee can relate himself to the overall situation, know what is required of him and why it is required.

Each supervisor should clearly understand his responsibility to keep his workers completely informed on all matters pertaining to their jobs. Division Construction Supervisors can issue memorandums or hold conferences, as needed, to inform their staff members of new information, changes in policy or to re-affirm established policies. Project Managers, Materials Supervisors, Office Engineers and men with similar responsibility can keep their workers informed by discussing the needs, as they relate to memorandums and directives received, on an individual basis.

Division Construction Supervisors need to be well informed of job activities. The way in which this knowledge is received can also aid in "tuning in" on the contractor--engineer happenings at the project level.

Memorandums written to contractors or others should contain specific details about events by setting down dates and times, quantities, circumstances, references to previous correspondence or conversations and, where applicable, the names and titles of individuals involved in the events. The following letter form is used as an example to point up the previously discussed guides.

P & Q Constructors
Route 1
Lingshire, Montana 09145

April 1, 1968

Subject: Project F-102(10)
Lingshire-East
(Always state the project designation)

Dear Mr. Poor:

/s/C.A. McDuff
Division Construction Supervisor

CAM:DM:pab ← typist's initials
← letter writer's initials
← Division Construction Supervisor's initials

cc: Project File
Project Manager

Other persons who have a legitimate interest in the letter should be sent a copy and their names listed under cc:

Each Division Construction Supervisor should discuss the memorandum writing procedure with his Project Manager and others under his direction who will be writing memos. A definite system should be established to suit the needs of the particular Division involved. The important thing here is to keep your people informed so that conflicting requirements will not occur. Memos from the Project Manager to the contractor should have copies sent to the Division Construction Supervisor.

The usual practice for written correspondence issuing from Helena to the Division Construction Sections is that the correspondence is signed by the head of the originating office. Similarly, the Division Construction Supervisor may wish to sign correspondence originating in his Division, remembering, of course, that the correspondence procedure should encourage and maintain rapid and clear communication. Some of the written matter may require the Division Construction Supervisor's personal review. Some may be standard submittals that he need not review personally. Letters, written by others, concerning matters not requiring the Division Construction Supervisor's personal attention, need only have an informational copy sent to him.

The above discussion on correspondence is offered to aid uniformity where uniformity is desirable.

04.02 Signatures on Claims and Correspondence

The manner in which certain disbursements and other official documents are to be signed on behalf of supervisory personnel (Helena department heads, Division Construction Supervisors, and Project Managers) should follow a uniform practice throughout the State.

The following examples show how diverse the practice has become over the years. In some instances, the supervisor's signature is affixed by rubber stamp accompanied by an employee's initials; in other instances, an employee is signing the supervisor's name with the employee's initials, and in other instances, the employee is signing his own name as being "for" the supervisor.

The following procedures are established in the interest of uniformity in these matters.

1. Supervisory personnel should designate one or more responsible employees (as required by circumstances) to sign on his behalf during absence. A memorandum to this effect should be sent to the Accounting Division as official evidence of the authority for such signatures.

2. Such designated employees should sign their own name to the documents instead of affixing the supervisor's name with the employee's initials.

3. Where the supervisor's name or title is printed on the document, the employee should sign his own name with the word "for" preceding the printed name or title of the supervisor: Example

s/James Smith
For Thomas Jones
Division Construction Supervisor

The above procedures apply to matters dealing with fiscal involvement such as FHWA documents, vendors claims, personal expense claims, etc.

More flexibility is necessary for signatures on other types of correspondence. A supervisor would not be expected to authorize a typist, stenographer or secretary to sign final documents on his behalf; however, he may wish to authorize such employees to sign his correspondence during his absence. The methods for handling signatures on correspondence will be left to the discretion of the supervisor involved. It is necessary, however, that the signature area show the name and title of the supervisor rather than of the employee signing the correspondence on behalf of the supervisor.

04.03 Telephone and Teletype

A state teletype system is available on work days from 8:00 in the morning to 5:00 p.m. and should be utilized for any correspondence where time is of the essence. A copy of the teletype should be sent to all other departments or divisions affected.

OFFICE OF DIVISION		
1130	Missoula	MSL
1230	Kalispell	KAL
2130	Butte	BTE
2230	Bozeman	BZM
3130	Great Falls	GFS
3230	Havre	HVR
4130	Glendive	GDV
4230	**Wolf Point**	WPT
4330	Miles City	MCY
5130	Billings	BLG
5230	Lewistown	LWN
Helena Office	Helena	HLN
Helena Lab	Helena	HLB
Helena Shop	Helena	HSP

The long distance telephone should be used only in cases where saving of time over letter mail is of sufficient importance to the State to warrant the expense of the call. Make telephone conversations as brief as possible and avoid extension of conversations into discussion of a nonessential matter. Person-to-person phone calls should be used where necessary.

Station-to-station calls are chargeable when the State exchange switchboard is reached even though the extension is busy and cannot be reached. For this reason person-to-person calls through exchanges are usually more satisfactory.

Telephone calls should follow the same channels as correspondence. The Project Manager should never call directly to the Helena office unless requested to do so or unless job conditions demand urgent attention and the Division Construction Supervisor is unavailable.

04.04 Radio

A network of radio stations has been established to provide radio communications throughout the State for those employees for whom it is absolutely necessary to maintain contact with their office maintenance personnel, communications personnel, Helena headquarters personnel, and Division Construction Supervisors, who will be away from their offices.

Radio communications should not be used for nonessential and noncritical material. Messages should be short, spoken directly, and with dispatch.

I-05 PROJECT MANAGEMENT

05.01 Personnel

A construction project is staffed by engineering aides, rodmen and instrumentmen who all are responsible to the engineer in charge of the project. The engineer in charge is usually a Project Manager, but may be an instrumentman who has been selected because of his proven ability.

The following lists of duties and responsibilities of Project Managers, Instrumentmen, Rodmen and Engineering Aides, are intended as guides. Varying conditions or circumstances may make it necessary or desirable to alter procedures to conform to special work requirements or local conditions. Since each man is responsible for making decisions regarding the duties and responsibilities assigned him, the supervisor must always provide sufficient authority so his employees can truly back up each decision they make.

A. Project Manager

General Duties and Responsibilities.

1. Project Manager is responsible for the supervision and coordination of engineering, inspection and documentation activities of the road or bridge contracts assigned to him.
2. Directly supervises a staff of engineers and inspectors in construction layout and inspection activities.
3. Coordinates the construction activities of prime and subcontractors, public utility companies, and other governmental agencies within the project limits.
4. Interprets plans and specifications.
5. Reviews changes in, or extras to, contracts involving original plans, quantities, items of work or specifications and issues work orders to contractors.
6. Makes recommendations regarding design and contract features prior to construction.
7. Originates reports of weekly progress and various estimates of completed quantities of work.

8. Prepares merit ratings and payrolls; approves time records and expense accounts for employees working under his supervision.

9. Represents the Department in contacts with the public, local governmental agencies, representatives of public utility companies and others directly concerned with construction activities on the project.

10. Gives engineering testimony at condemnation hearings.

11. Inspect and/or approve construction procedures and practices on the project.

12. Assign and requisition personnel, equipment, supplies and materials for the stakeout and inspection of the construction projects.

13. Coordinates the work of several contractors where adjacent contracts are under his direction.

14. Accompanies F.H.W.A. representatives on their periodic inspection of work on projects under his direction.

15. Maintains complete liaison between the Division Construction Supervisor and the project activities.

Qualifications.

The Project Manager must be qualified by education in terms of college training or "in-service-training", and sufficient experience to demonstrate his ability to manage one or more projects assigned to him.

B. Instrumentman

General Duties and Responsibilities.

1. Directs and lays out work for one or more construction staking crew(s) usually participating in this work.

2. Coordinates staking work with the contractor to obtain surveying efficiency and avoid construction delays.

3. Supervises various rodmen, engineering aides or other instrumentmen assigned to him by the Project Manager to stake slopes, culverts, clearing, gravel, grading right-of-way, references, levels, paving, etc.

4. Makes detailed review of plans and specifications for their completeness and accuracy. Prepares and supervises preparation of field notebooks.

5. Prepares or coordinates preparation of reports and forms documenting project operations and quantity measurements.

6. Is capable of and frequently does prepare the weekly progress reports, work orders, monthly estimates, etc.

7. Personally handles some of the more critical inspection duties.

8. Periodically contacts inspectors to check on problems.

9. Operates or directs operating of surveying instruments to provide all alignment and elevation for highway construction.

10. Computes and checks other computations for quantities, survey details and estimates.

11. Assists in training newly hired personnel.

12. Settles disputes between inspectors and contractors representatives.

13. The instrumentman is directly responsible to the Project Manager, but on occasion may be placed in charge of a project in which case he is responsible to the Division Construction Supervisor.

14. An instrumentman is truly the "Party Chief" set in charge and made responsible, by the Project Manager, for all surveying, inspection, computation, note keeping and documentation and takes charge of the project in the absence of the Project Manager.

Qualifications.

The instrumentman is qualified by education in terms of college training or in-service and on-the-job-training, or an approved combination of these qualifications.

C. Rodman

General Duties and Responsibilities

1. Serves as an inspector of grades, culverts, asphalt streets, concrete slabs, concrete or bituminous plants, drainage structures or gravel surface courses.

2. On grading work, observes clearing and grubbing work for completeness and conformity to plans; ascertains that earth moved is within balances shown by mass diagrams, that subgrade has appropriate moisture content and is sufficiently compact, and that unsuitable earth, such as that high in organic content, is removed; verifies that Contractor has proper equipment for spreading, shaping and compacting of gravel surfaces; checks pipe culverts to see that they are laid at specified grade and that joints are properly sealed.

3. Checks temperature of bituminous mixes on asphalt streets for conformity to specifications and yield; ascertains that operations of spreading and rolling are properly co-ordinated.

4. Inspects concrete slab construction operations such as setting of forms, subgrade compaction, joint installations, presence and type of reinforcing materials, manhole heights, and paving machinery; inspects equipment for condition and adjustment. Computes proportioning of materials, checks yields, observes condition of concrete and bituminous mixes and makes slump tests in concrete, inspects contractors' facilities for storing and transporting cement and bituminous materials.

5. Assists in placing stakes for culvert construction on large drainage structures; inspects culvert materials and workmanship, as instructed, for compliance with specifications.

6. Rodmen are responsible to the Project Manager through their supervision by instrumentmen.

Qualifications.

A Rodman must be qualified by education in terms of college training or in-service training but primarily have sufficient on-the-job experience to properly handle the surveying, inspection and computation duties and responsibilities assigned to him.

D. Engineering Aide

General Duties and Responsibilities.

1. Engineering Aides may be supervised by rodmen, instrumentman or the Project Manager, to whom they are directly responsible.

2. Gain increasing skills in the use and understanding of survey-implements (steel tapes, level rod, range pole, etc.).

3. Gain knowledge of plans and specifications that enable them to perform some of the less complex testing and inspection services.

4. After successfully completing a trial period, may begin planned advancement through the various steps in rank.

5. Assists in performing construction surveys and construction inspection.

Qualifications.

Engineering Aides must have sufficient on-the-job experience to properly handle the progressively responsible duties assigned. The various "State sponsored" night courses or formal schooling will greatly aid in accepting and performing the more technical aspects of this position.

E. Field Office Personnel

No job title presently exists to define and categorize the duties and responsibilities of the field office engineer. However, in spite of this apparent deficiency, the need remains to staff a field office with a man or men sufficiently skilled in survey note keeping and familiar with pay quantity determination and documentation. The more complex projects especially deserve the full time attention of a trained office man. This individual may be an instrumentman or a competent rodman. When a project requires an office man, the following list describes some of the uses to which he may be put.

1. Performs computations to aid the surveying, staking and remeasurement of the project.

2. Audits the notebooks, weigh tickets, punch cards and miscellaneous records for proper validation and documentation of pay quantities.

3. Prepares the weekly progress report and other period reports for submission.

4. Helps the Project Manager in preparing change orders and extra work orders.

5. Helps in preparation and checking of the monthly progress estimates.

6. Compiles earthwork notebooks for electronic computation.

7. Assures that project files have received and contain test reports for the various materials incorporated in the project.

8. Correlates all incoming correspondence, field notes, etc., and keeps the Project Manager informed on general progress of project.

9. Supervises inspectors and survey personnel in any office computations. Field office personnel should have experience similar to that of an experienced instrumentman or highly qualified rodman with detailed knowledge of units of work, methods of measurement computation, testing and general project procedures.

F. Working Conditions and Conditions of Employment

The main portions of policy on personnel are found in the Personnel Manual from which a few of the more important concepts have been excerpted as are shown below:

1. The Construction Bureau employs several hundred Engineers, Inspectors, Instrumentmen and other technicians who are assigned to various Divisions throughout the State for work on construction projects. Since the volume and location of the work are continually changing, employees must bear in mind that it may not always be possible to be assigned within easy driving distance of their homes. There is no guarantee that the employee will stay within the Division to which he is originally assigned; consequently, construction field personnel must be continually aware that they may be assigned anywhere within the State at any time. Wherever possible, the location of the employee's home will be taken into consideration when reassignments are necessary.

2. The standard work week for highway employees is from Monday through Friday, 8:00 a.m. to 5:00 p.m., 40-hour week. However, the hours at which the employee reports for work and is released may be set by the Division and/or Supervisor and could be different from the normal 8:00 a.m. to 5:00 p.m. It is also possible that a work week could run from Sunday through Thursday, or from Tuesday through Saturday, depending on the requirements of the work.

It is the policy of the Montana Department of Highways to work employees more than the standard eight-hour day or 40-hour week only for temporary periods of time until additional employees can be hired, or for emergencies. Continued overtime shall be used only if no alternative method of providing the necessary manpower can be utilized. The hours of overtime for construction field employees will fluctuate according to contractor's schedules.

3. The Department of Highways makes no attempt to regulate the private life of any of its employees but where an employee's private life is in serious conflict with Department policy, the employee may be asked to resign or will be dismissed from his position with the State. The Department of Highways does expect each employee to conduct himself in a manner that brings no censure to either himself or the Department.

Dismissal or resignation may be required where employees are dishonest; or have accepted cash or gifts from the contractor; or worked for both contractor and the State; or are holding or intend to hold elective public office of a partisan political nature; or have other employment which conflicts with their ability to ably perform their State duties in an unbiased objective manner.

G. General Inspection Duties

An inspector classification does not presently exist since each individual assigned to a construction project, from the Project Manager to the Engineering Aide I, will at some time be required to inspect the contractor's work. Therefore, the following description of an inspector's duties is intended for the use of any individual performing inspection work.

An inspector employed by the Montana Department of Highways is empowered, by the standard specifications to reject defective materials and suspend performance of improper work (work done which does not conform with the plans or specifications). He is authorized to inspect any part of the work, equipment, materials and method and is not to be denied access to work areas, material sites or equipment unless an unusual hazard exists or temporary conditions prevent a thorough inspection.

An inspector must function to see that work is done in accordance with the terms of the contract. If the contract calls for certain things that are wrong and inadvisable the inspector is not authorized to improve them. He can not enlarge, revoke, alter or relax any requirement of the contract nor issue any instructions contrary to the contract terms.

The inspector performs many duties. He may be required to keep force account records of time spent or materials furnished for the work done. He may have to function as a "gravel checker," a grade inspector, a compaction and proctor tester, perform plant and equipment inspections, observe culvert, guard rail and sign installation or other numerous inspection duties. He can not be everywhere at one time and, therefore, he must learn what to watch for, how things should be done, how much time it takes to perform various parts of the work. He must be able to detect pending troubles as well as present deficiencies so that he is prepared to make decisions or refer the matter to his superior. Prompt action is very necessary to promote good contractor-state relations and to avoid unnecessary delays. Delays to the contractor are or can become very costly and provide the basis for a claim should the entire responsibility for the delay be attributed to an inspector.

A good deal of practical experience is necessary if an inspector is to refrain from being either too particular or lax and careless. An inspector who demands perfection where perfection is unattainable or one who is so lax that unacceptable work is continually being done will have everyone antagonistic toward him. A contractor will generally cooperate with an inspector whom he trusts, who is sincerely striving to be fair and whose knowledge he respects. An unreasonable inspector who doesn't understand the contractor's problems will arouse his anger as surely as a careless inspector will arouse the contractor's disdain. An inspector who is fair, firm in his decisions, and honest in his work will no doubt have problems but his work will be respected and he will more easily gain any cooperation needed in solving his problems.

It is seldom possible for a contractor to make every detail absolutely perfect on a large job where hundreds of things have to be done. The inspector must use good judgment and allow for the reasonable tolerances that do exist in construction work. The required tolerances and accuracy are usually well defined by the specifications or detailed on the plans (ie. compaction requirements, aggregate gradations, pavement thickness, structural dimensions, etc.). It is the inspector's duty to require a contractor's adherence to the known tolerance requirements but where any doubt exists he should consult with the engineer-in-charge before making a decision.

05.02 Project Files

The Project Manager or other responsible engineer placed in charge of a project is required to maintain an up-to-date file of all project activities. The files must be neat and orderly to provide quick reference to all details small or large. Occasionally auditors or engineers have cited deficiencies in pay quantity documentation only because they couldn't interpret the project filing system (pay item, documentation did exist but could not be found). In order to establish a consistent and uniform filing system throughout the State, the following list of file-folder headings is presented as a guide. One project will probably vary from another in complexity and amount of record keeping necessary. Some projects may require a more thorough breakdown than is presented, others less. Whatever the record keeping requirements are, the file system should generally be patterned after that shown below:

Folder Title and General Contents

Project Correspondence
  General Correspondence
  Division Correspondence
  Headquarters Correspondence

Contractor Correspondence
  Notice to Proceed
  Preconstruction Conference Report
  General Directives
  Approval of Methods and Equipment
  Erosion and Siltation Control Plan
  Approval of Erosion and Siltation Control Plan

Federal Highway Administration
  Inspection Reports
  Policy and Procedure Memorandums

Contractors Payrolls and Labor
  Payroll Transmittals and Affidavits
  Labor Reviews and Spot Checks

Construction Contracts
  Contract and Bond and Project Agreement
  Sub-Contract Agreements
  Insurance Information

Contract Changes
  Change Orders, Extra Work Orders, Force Account Records
  Supplemental Agreements
  Correspondence

Contract Time
  Suspend and Resume Orders
  Weather Data
  Summary of Time Extensions

Progress Records
- Progress Reports
- Pay Quantity Documentation (Estimate of percent complete)

Monthly Progress Estimates
- Progress Semi-Final and Final Estimates

Real Estate Data
- R/W Agreements (parcels, easements, construction permits)
- Borrow Agreements and Permits
- Borrow Pit Depletion Reports
- Fencing

Utility Data (1 folder for each Utility Company & R.R. involved)
- Various Agreements
- Payments, Extra Work Orders, Flagging Charges
- Records of Utility Meeting
- General Correspondence
- Salvaged Material Reports

Materials Certification
- Commercial Testing Lab Reports (pipes, steel, various fabricated products)
- Certificate of Compliance (except asphalt products)
- Platform Scale Certification (copy of statement that scale was checked)
- Platform Scale vs Belt Scale Comparisions
- Other Scale Certification

Preconstruction Test Records
- Soils Tests
- Aggregate Tests (Pit Reports)

Reclamation Records
- Gravel Pit and Borrow Area Reclamation Plan and Sketch

Earthwork Testing
- Compaction Tests and Summary

Base Aggregate Test Records
- Base Aggregate Testing Reports

Top Surfacing Test Records
- Top Surfacing Test Reports

Plant Mix Surfacing Records
- Plant Mix Aggregate Test Reports
- Mineral Filler Test Reports
- Daily Plant Forms

Asphalt Cement
- Materials Certification
- Bills of Lading Invoices
- Materials Test Reports

Liquid Asphalt
- Materials Certification
- Materials Test Reports

Miscellaneous Testing Records
- Miscellaneous Sample Test Reports (water, rip-rap, additives, etc.)
- Various State Laboratory Testing Reports (except asphalt, concrete, gravel, soils)

Contractors Equipment Inspection Records
- Reports of Equipment Inspection, (Plant Calibrations, Roller Weight Determination, etc.)

FHWA Progress & Final Record Sampling Data
- Various Sampling Designations
- Progress and Final Record Sampling and Test Results

Final Inspection & Acceptance Data
- Reports of Final Inspection, State and FHWA
- Reports of Surfacing Depths, Core Depths, etc.
- Certificate of Completion
- Statements of Substantial Compliance

Concrete Construction
- Concrete Cylinder Submittals
- Breaking Strength Reports
- Cement Test Reports
- Concrete Inspection Records

Safety & Industrial Accident Data
- Reports of Accident, Occurrence, etc.

Personnel
- Merit Ratings
- Overtime and Straight Time Records
- Sick Leave, Vacation, Time Off
- Payrolls
- Personnel Correspondence
- Personnel Manual

Surveying & Equipment Inventories
- Equipment Inventory Reports
- Requisitions
- Repair and Adjustment Data

05.03 Quantity Documentation

A. General

An inspector's dated signature on identified records provides the answer to the obvious question of who inspected what item and when. Although dates and signatures are extremely important and will continue to be stressed, the documentation processs consists of other important features. Documentation is a written record showing measurements, observations, calculations and all pertinent information made during the life of the contract. Webster defines a document as "Anything printed, written, etc., relied upon to record or prove something". In highway construction we want to prove that measurements were taken, that any payments made have adequate written support, that items or work were actually inspected, signed and dated, etc. Adequate documentation will always serve a temporary need if the documentary process is designed for future use of other engineers or auditors not intimately acquainted with the project.

Expert field engineering crews can do very careful, precise work. Work which entails a great deal of rapid mental activity and a vivid memory. Many good engineers are thus enticed to recall past events by relying on their visual image, their good memory and a scanty set of notes made to satisfy an immediate need on a project. Often, this type of "reminder" writing will result in an informational void not intelligible on later review by other engineers or even the note maker himself!

Documentation notes must stand by themselves to be capable of intelligent interpretation without resorting to a question and answer session with the person recording the notes.

Records, that are ambiguous, incomplete or unclear, will be returned to the field for clarification and correction. Erroneous or unsigned records result in payment errors, incorrect design, inability to defend the work to others and general mistrust of that field crew's work. In contrast, properly made notes and good documentation will improve the field crews confidence in themselves and promote the trust of headquarters personnel for that crew's good work.

Remember that many persons may be using the field information but none of these individuals are mind readers, some have very poor eyesight and others have a tendency to substitute their own ideas when the correct information is lacking. Make your notes clear, legible, neat, honest, self-explanatory, complete and self checking. Careful documentation results in correct interpretation.

B. Notebooks, Weigh Tickets, Punch Cards, Progress Estimates

1. Gravel Punch Cards - - - - require written signature-last name sufficient

   The use of punch cards for gravel operations require that two cards be retained for validation and documentation, one card to be signed by the scaleman and the other by the roadman.

2. Water Punch Cards - - - - require written signature-last name sufficient

3. Rolling - - - - require written signature - last name sufficient

4. Flagging or Traffic Control Card - - - - require written signature - last name sufficient

5. Gravel Ticket - Form No. 124

   Do not initial tickets except at the time of actual weighing. Written initials of inspectors on each copy (listed below) are satisfactory due to the time used in writing a full signature.

   WHITE - Contractor Copy - Scaleman & Roadman Validation
   YELLOW - Road Copy - Scaleman & Roadman Validation
   PINK - Scaleman Copy - Scaleman Validation Only

6. Notes

   A. Transit

   On first page for each day list staking party personnel, date and weather at top of page. Chief of party or notebook keeper should sign his name at bottom.

   B. Cross Sections

   Same as Transit Notes.

   C. Grades

   Each page should show signature of person or persons who computed and checked the notes.

D. All surfacing Gravel Notes & Oiling

Remarks column should show name of persons involved such as: Tester, Scaleman, Roadman, Plant Inspector, Distributor, etc. Notes should be signed at the end of each shift or days' operation by the person or persons that records, posts and checks them.

E. Culvert Notes (CSN 25)

The staking party should be shown for each installation at top of the left-hand page.

Inspector should date and sign the note page or pages for each installation.

Computer and checker of excavation quantities should both show written initials for each installation.

If the installation involves other items done at other times, such as: riprap, cutoff walls, edge protection, backfill, etc. - notes should be dated and signed by the inspector for each item.

F. Signing Notes

Separate staking notes should be made for each sign installation, not an overall summary. Show staking party, date staked, date installed, and be signed by inspector of installation.

G. Miscallaneous Item Computation

All notes involved with computation of quantities, whether by individual measurements or by lump sum, should be dated and signed by persons responsible for their recording, **accuracy**, inspection, etc.

In those cases where written initials are allowed, the identification of the initials should be shown in the front of the book for the particular item involved.

7. Progress estimates are a continuing summary of partial payments for all contract items on which work has been performed. The majority of common pay items (unclassified excavation, overhaul, clear and grubbing, culverts, aggregates, asphalt, signs, etc.) have staking and installation notes to back-up any payments made. However, each contract item, especially lump sum and removal items, must also have notes made at the time work is performed to verify that an item was approved, inspected, properly installed and payment allowed has been justified, by documents. Prior to writing this manual, many different ways were used by Project Managers to summarize the monthly payments made. A few engineers use a columnar sheet to record the work performed each week, others use a form with spaces,provided for a weekly estimate of work performed, still others have no formal accounting system but use the weekly progress report to document any progress payments made.

The preferred accounting method consists of a systematic, stepwise approach leading toward and documenting each monthly payment made. It begins with field inspection and recording or estimation of a pay quantity; this field notation becomes a permanent record on a week-by-week summary of work accomplished. Progress reports and monthly progress estimates are then compiled from this summary. For instance, if we assume that unclassified excavation quantities were being developed for a progress estimate, the flow of information should follow the pattern in Figure I-1 below. Other items would be similar.

A columnar accounting sheet can be used to a very good advantage for recording the weekly quantities of work performed for every contract item and each work order. The use of this type of sheet is recommended. It should be titled and filled in similarly to the example shown below and be "backed up" with any adding machine tapes calculation sheets or other records used in preparing it.

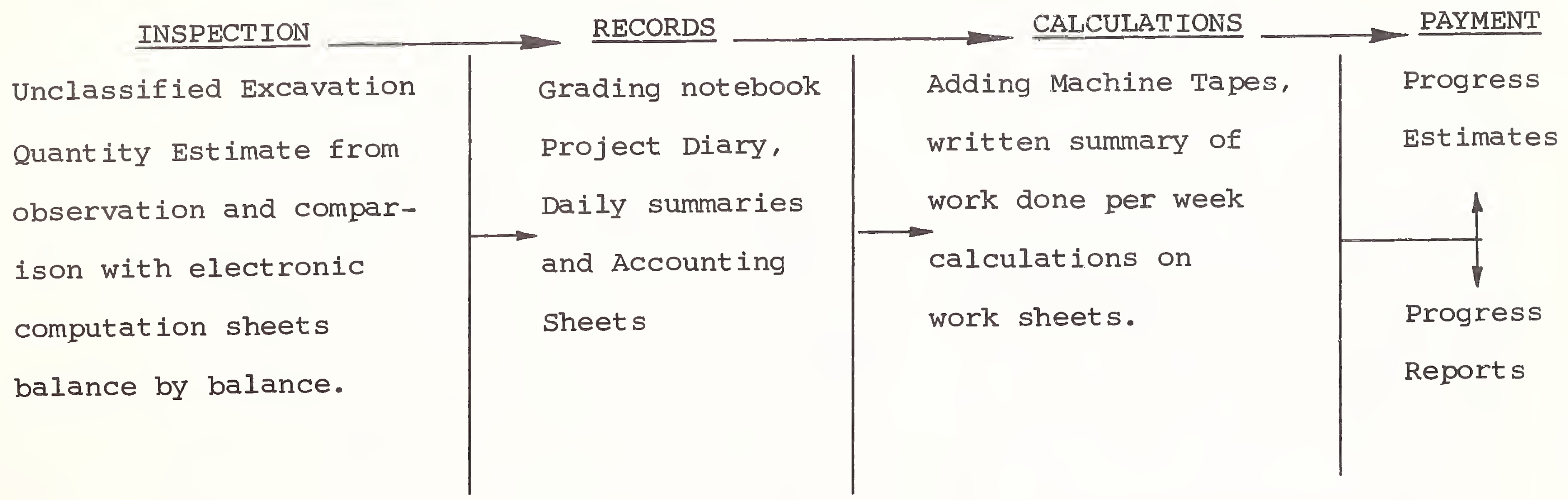

INSPECTION
Unclassified Excavation Quantity Estimate from observation and comparison with electronic computation sheets balance by balance.
RECORDS
Grading notebook Project Diary, Daily summaries and Accounting Sheets
CALCULATIONS
Adding Machine Tapes, written summary of work done per week calculations on work sheets.
PAYMENT
Progress Estimates
Progress Reports

Fig. I-1

WEEKLY ACCOUNTING SUMMARY - PROJECT AGREEMENT $894,000

Weekly Quantities & Amounts	Item 1101 Uncl. Exc. 5,000,000 C.Y.@$0.40	Item 2512 3/4"Type 'A' Top 80,000 Tons @$2.00
	QUANTITY	QUANTITY
uantity for wk. ending 3-1-67	5000	
otal Quantity to Date	5000 (0.1%)	
uantity for wk. ending 3-8-67	20,000	
otal Quantity to Date	25,000 (0.5%)	
uantity for wk. ending 3-15-67	40,000	
otal Quantity to Date	65,000 (1.3%)	
uantity for wk. ending 3-22-67	40,000	
otal Quantity to Date	115,000 (2.3%)	
uantity for wk. ending 4-1-67	40,000	20,000
otal Quantity to Date	155,000 (3.1%)	20,000 (25%)
uantity for wk. ending 4-8-67	60,000	20,000
otal Quantity to Date	215,000 (4.3%)	40,000 (50%)
aid on Estimate No. 1		
uantity to Date 4-11-67	215,000	40,000

Fig. I-2

05.04 Project Diary

The Project Manager will keep a daily account of the weather conditions, construction activities, inspection problems unusual events, etc., in the Project Construction Diary. The Project diary can become a valuable tool in setting future claims or lawsuits and should be factual and maintained in a neat, legible manner. Write the diary in ink or ballpoint and sign it after each day's entries. A few suggestions for making entries are as follows, other suggestions are shown in the "example" diary pages in Figure I-3.

1. Record the dates, high and low temperature, weather and general effect of weather on construction progress.

2. State the names of inspectors, engineers or crew activities and their job assignments for that day.

3. Briefly explain the contractors working schedules, operation and equipment used. A complete record of the contractors equipment should be kept, which should include, date each piece of equipment arrived on the project, standby time, days worked and date equipment leaves the project.

4. Each inspector should keep a permanent diary in which he includes a daily account of the equipment and work he inspects. This information can be incorporated into the project diary by the Project Manager. The statement "Equipment same as (some date)" should not refer to an equipment list which is over one week old. A new list of the equipment that is working should be entered in the diary by the inspector at least once a week.

5. Record orders given to the contractor, important directives should be followed-up with a confirming memorandum restating the verbal directive. Any differences over the work, quality, performance and decisions made should be recorded.

6. Record any information involving changed conditions, extra or additional work needed, delays caused by the contractor, delays to the work caused by others, reasons for delays, impending or existant claims.

7. Record dates of closing or opening detours, condition of detour roads, hazards to traffic and detour signing problems.

8. Enter any additional information which would be of value as a project record. Estimates of quantities completed each day that would not ordinarily be recorded in notebooks.

9. The Federal Department of Labor considers the project diary as part of the "basic record". Therefore, it is wise to include the date, name and nature of any labor complaint.

Examples of pages from a project diary are shown in Figures I-3 as a guide in preparing daily diary entries.

05.05 Project Offices and Field Laboratory

The project offices and field laboratory will be furnished by the Department of Highways, including fuel for heating. The contractor is required to furnish water and electricity.

Trailers are made available on a lease-purchase basis for use as field offices and are especially designed as field laboratories. These trailers should be available on request.

It is expected that good care be taken in using and transporting these trailer houses. They must be kept clean and well maintained at all times.

The maintenance is the responsibility of the Department of Highways and any necessary repairs such as broken windows, water pumps, electric systems, stove repairs, etc., must be called to the Division Construction Supervisor's attention.

Quite often, the only contact some of the public has with the Department of Highways is through the personnel assigned to a construction project. A first impression may leave a lasting image in the minds of a visitor in the project field office. Each Project Manager can promote a good impression of efficiency and concern about expenditure of public funds by maintaining a neat clean orderly office.

05.06 Internal and Interdepartmental Relations

Although not generally considered as public relations, the relationship between employee and supervisor properly falls under the subject of project management. It is very important that the supervisors be kept adequately informed on pertinent facts so that they are not placed in an embarrassing position of learning from outside sources what goes on in the Division. The Division must also keep the Construction Bureau informed, particularly on unusual situations and events.

Employees must know precisely what their responsibilities are and, equally important, they must have the authority necessary to handle these responsibilities.

Date 7-22-68 Average Temperature 55° To 78° °F

Weather (Clear — Rain — Etc.)

General Effect of Weather on Construction Progress

Light rain (0.04") did not hamper progress occurred from about 2:30 P.M to 2:50 P.M

Engineering Crew's Activities

Wolf in office preparing notes & working on quantities

Branton inspecting grade – Baker inspecting pipe installation

Timken taking compaction tests & inspecting grade & Scow helping

Matovich inspecting S.P.P.C. at sta. 646+13. Ellsworth on Utilities

Waggoner & remaining crew staking borrow area & bluetopping sta. 501-525

Contractor's Operation, Equipment and Working

Schedules: 16 men worked 1-9 hour shift

Equipment is satisfactory – Equipment is as listed on 6-29-68 except for the following units brought on the job this A.M. – 2 D9 push cats w/ dozers, 3 DW 21, 2 cat drawn sheepsfoots 1-5000 gal. gravity feed water truck, 1-#12 patrol & 1-#16 patrol, 1-light plant

General:

The contractor is excavating in bal. between 555-618± the soil is damp needing little additional moisture but some processing is being used to incorporate water & make uniform. Contractor has agreed this is necessary. Moved about 5600 c.y. today. Most compaction tests met specs for density some areas needed more processing to make the 95% reqmt.

Instructed contractor to subexcavate excessively wet & now unsuitable material near subgrade elev. at sta. 602+10 to 602+40 Got about 200 c.y. which might be ok near outside of subgrade when dry.

All utilities were completed today. Salvaged items are listed & stored in shed opposite sta. 700 owned by Mr. Barkley Who is allowing use free of charge.

Compaction tests on all pipe installations are ok

B.P.R. area engineer Mr. Able observed compaction testing & was satisfied with the method used & frequency. Project files appeared satisfactory to him also. Discussed subdrain to correct seepage water about 20' left of ℄ @ sta. 602+35. Will observe this area further when grade has been completed & then review again with Mr. Able. Mr. Anderson, Div. Engr. agreed to this wait & see policy providing no delay occurs to contractor.

Signature Antone Waggoner Title R.E 2

FIG. I-3

It is strongly recommended that the Project Manager hold a short staff meeting at the beginning of each week at which time he briefs his assistants on the schedule of operations for the week, the status of the contract and information which will enable them to answer the various questions that may arise.

Another important phase of internal public relations is the necessity for working harmoniously with other departments within the organization. It should be borne in mind that the people in other departments do their work with information available to them just as construction forces do. They too have problems in their work. They too do their best. If there is a difference of opinion on some part of the project whether it is design, manner specified for handling traffic, or some other feature, the Project Manager should approach the other party with an open mind and discuss the problem with him. An understanding of the functions and problems of other departments as well as how those departments fit into the organization is a most important benefit to the individual as well as to the Department of Highways as a whole.

The construction employee who is most likely to advance in his career is one who masters his immediate assignment, prepares himself for more important work, takes pride in his employment, and conscientiously tries to follow the regulations and policies of the Department of Highways.

In the Highway organization there can be but one "commander in chief"; in the Division there can be but one administrative head. Important regulations and policies must, necessarily, be determined at the top level, and are made with the best interests of the State-wide Highway development in mind. If the Department is to operate at maximum efficiency, there must be no willful divergence from the regulations and policies established at top level.

One may differ in opinion from a top level determination and may freely present reasons for its reversal, but as long as the opinion stands and is effective it should be observed scrupulously and supported loyally. Any employee who is unwilling to abide by this rule is not a good employee in the cause of our highway engineering effort.

05.07 Employee Conduct

1. It is against Montana Department of Highways policy for any employee to accept any type of gratuity which may be of any financial benefit. This firm, exclusive policy has been adopted necessarily and it shall remain in force. This policy has been made to protect both the employee and the Department of Highways from any moral obligation or intimidating obligation that may result from an employee accepting gifts from a contractor.

2. Political activity that is in direct conflict with the Hatch Act is absolutely prohibited. The following list outlines some of the political activities that are prohibited and those which are allowed.

   The following are among the forms of political activity PROHIBITED on the part of Federal, State, or local agency officers and employees whose activities come within the scope of the Hatch Act:

   a. Serving on or for any political committee, party or other similar organization.

   b. Soliciting or handling political contributions.

   c. Serving as officer of political club, as member or officer of any of its committee, or being active in organizing it.

   d. Serving in connection with preparation for organizing or conducting a political meeting or rally, addressing such meetings or taking any other active part therein, except as a spectator.

   e. Engaging in political conferences while on duty or canvassing a district or soliciting political support for a party, faction or candidate.

   f. Manifesting offensive activity at the polls at primary or regular elections, soliciting votes, assisting voters to mark ballots.

   g. Acting as recorder, checker, watcher, or challenger of any party or faction.

   h. Serving in any position of election officer in which partisanship or partisan political management may be shown.

   i. Publishing or being connected editorially or managerially with any newspaper generally known as partisan from a political standpoint or writing for publication or publishing any letter or article signed or unsigned in favor of or against any political party or candidate. (ownership entirely disassociated from editorial control or managerial activities limited entirely to business management would not be regarded as being within this provision.)

j. Becoming a candidate for nomination or election to office, Federal, State, or local, which is to be filled in an election in which party candidates are involved.

k. Distributing compaign literature or material.

l. Indicating or circulating political petitions including nominating petitions.

m. Assuming political leadership or becoming prominently identified with any political party or faction or with the success or failure of any candicate for election to public office.

"The following are general statements concerning certain activities which are considered to be PERMISSIBLE on the part of all officers and employees subject to the Hatch Act."

VOTING - The direct language of the law specifically provides that all such persons retain the right to vote as they may choose.

EXPRESSIONS OF OPINION - The right to express political opinions is reserved to all such persons. This reservation is subject to the prohibition that such persons may not take any active part in political management or in political campaigns.

CONTRIBUTION - It is lawful for any officer or employee to make a voluntary contribution to a regularly constituted political organization provided such contributions are not made in a Federal building or to some officer or employee within the scope of the above quoted statutes.

POLITICAL PICTURES - It is lawful for any officer or employee to display a political picture in his home if he so desires.

BADGES, BUTTONS AND STICKERS - While it is not unlawful for an officer or employee to wear a political badge or button, or to display a political sticker on his private automobile (except where forbidden by local ordinance), it is felt inappropriate for any public servant to make a partisan display of any kind on duty and conducting the public business.

SIGNING PETITIONS - An officer or employee subject to the Hatch Act is permitted to sign petitions including nominating petitions, as an individual, without reference to his connection to the State or Federal government.

CIRCULATING PETITIONS - While it is unlawful for an officer or employee subject to the Hatch Act to initiate or circulate a nominating petition, it is not a violation under the Hatch Act to circulate a petition initiating a law that is later placed on the ballot at an election to be voted upon by the electors of the State. (This means questions relating to the Constitutional Amendments, references, approval of municipal ordinances, and others of a similar character which are not specifically identified with any national or state political party.) However, no petitions may be circulated by employees of the Department of Highways while on duty.

3. Any officer or employee of the State Department of Highways must have in his possession a valid and current Montana driver's license when he is operating any vehicle owned by the State. Employees shall operate State vehicles in a safe and prudent manner. State Highway employees are often looked upon both by the public and the Department of Highway supervisors as persons who must set examples on driver practice for all other people in the State. When parking vehicles for the evening do not park them near a bar. If a bar and a restaurant are together and the restaurant is the only eating place in town, then it is best to park the vehicle near the restaurant, complete the meal, and repark the vehicle in a more appropriate location. This is a general Department of Highways policy. It may be changed from time to time as deemed necessary to regulate employee conduct regarding State vehicles.

4. Complaints received from the general public are for the most part referred to the Division Construction Supervisor and the Project Manager most familiar with the situation. When receiving a complaint be prompt in contacting the person complaining. To delay in the hope it will "cool down" may only add more fuel to the fire if the person complaining feels that he is being ignored. It is best to talk personally with the person making the complaint. Often it is just something he wants to get off his chest.

Listen, and above all, be courteous. If you can make a decision on the matter, advise that person what can be done, when it will be done, and then prepare a brief memo advising all interested persons as to how the matter was conducted. If the matter cannot be decided, inform the person complaining that his problem is beyond your authority, tell him what you intend to do, and promptly prepare a brief report stating the situation, then send this report through channels. Remember, never lose your temper nor your composure.

5. It is essential that all persons concerned with the project perform their functions as carefully, thoroughly, and honestly as possible in order to assure high quality, durable, construction that conforms with the approved plans and specifications. A high degree of reliability can be placed on statements and representations made by engineers, contractors, suppliers, and workers on the highway project when their duties and functions are performed honestly. Willful falisfication, distortion, or misrepresentation with respect to any facts related to the project is a violation of federal law. To prevent any misunderstanding regarding the seriousness of these and similar acts, the following is quoted from Title 18, United States Code, Section 1020, which reads in part as follows:

> "Whoever knowingly makes any false statement, false representation, false reports or false claim with respect to the character, quality, quantity, or cost of any work performed or to be performed, or materials furnished or to be furnished in connection with the construction of any highway or related project...or whoever knowingly makes any false statement or false representation as to a material fact in any statement, certificate, or report submitted...shall be fined not more than $10,000.00 or imprisoned not more than 5 years, or both."

05.08 Construction Engineering Costs

Engineering costs on construction contracts frequently overrun the 10% provided by Federal money. The State must absorb all costs over 10% on interstate construction contracts. Engineering costs up to 15% can be re-couped on primary, secondary and urban contracts but these overruns must be substantiated before the State will be reimbursed. After justification is submitted and accepted the project agreement is modified to include overruns above the 10% up to the maximum of 15%.

Justification is to be submitted in a standard format and should be sufficient to allow a person, who is unfamiliar with the project, to gain a reasonable insight into the causes for the overrun. Specific dates, time and length of shifts, varying number of personnel, general weather and rainfall information, etc., should be mentioned to verify the causes for increased cost.

The justification for overruns on each project is to be submitted when the project is completed.

The information desired is as follows:

Location:	A brief description of the geographical location of the project.
Type of Work:	Bridge; Grading, Aggregate Surfacing, Drainage and Plant Mix Bituminous Surfacing; Signing; etc.
Contract Amount:	Contract Amount - Also Amount of Construction Engineering Costs and Percentage.

1. Moving, Travel, and Per Diem Costs: Reasons for the above charges (if existent) to the project. For example: Payment of expenses in outlying areas where housing is unavailable. Mileage paid for travel to and from the project becomes significant as the distance to the project increases.

2. Construction Season: When the contract for the project was let; when work was begun and completed; major delays caused by inclement and/or wet weather. For example: Unseasonal weather may prohibit major construction work, increasing time for completion and thus lengthening the time engineering personnel and their equipment are required.

3. Prosecution of the Work: An evaluation of the contractors operation, including examples of inefficiency. For example: Double shifting may require more personnel and equipment, or payment of overtime.

4. Engineering and Inspection Required: Factors contributing to increased engineering and inspection requirements. For example: Double shifting increases costs. Long shifts and week end work causes overtime pay. Projects with varying work items and diversification of work areas have many activities happening simultaneously which increases the number of inspectors.

5. Special Conditions: Conditions of the projects which require engineering and inspection beyond what is considered routine; terrain, type of work or any factor which would increase engineering and inspection requirements out of proportion to the value of work performed; miscellaneous items not included elsewhere. For example: Difficult terrain require more man hours for construction layout than flat ground. Inspection in difficult terrain is usually more time consuming and construction progress is slower. This also lengthens inspection time.

You may want to add to or improve this form by your own ideas, so feel free to do so.

CHAPTER II
CONTRACT ADMINISTRATION

CONSTRUCTION MANUAL

CHAPTER II

CONTRACT ADMINISTRATION

II-10 DEFINITIONS AND TERMS

10.00 References
10.01 General
10.02 Approved
10.03 Claim
10.04 Joint Venture
10.05 Order of the Engineer
10.06 Overbreak
10.07 Overhead
10.08 Production Chart
10.09 Right of Access
10.10 Roadway Prism
10.11 Shoulder
10.12 Subcontractor
10.13 Substantial Compliance
10.14 Tolerance
10.15 Work

II-11 SCOPE OF WORK

11.00 References
11.01 General
11.02 Changes
11.03 Detours and Maintenance of Traffic
11.04 Use of Materials Found in Work

II-12 CONTROL OF WORK

12.00 References
12.01 Authority of Engineer
12.02 Contractors Equipment, Personnel and Operation
12.03 Approval of Subcontractors
12.04 Lines and Grades
12.05 Inspection
12.06 Rejection of Defective or Unauthorized Work
12.07 Claims for Adjustment and Disputes
12.08 Post Grading Inspections on Interstate Projects
12.09 Pre-Completion Inspection of Interstate Projects
12.10 Final Inspection

II-13 CONTROL OF MATERIALS

13.00 References
13.01 Contractors Responsibilities
13.02 Use of Locally Available Materials
13.03 Materials Acceptance or Rejection

II-14 LEGAL RELATIONS AND RESPONSIBILITIES

14.00 References
14.01 Laws to be Observed

CHAPTER II

CONTRACT ADMINISTRATION

II-14 LEGAL RELATIONS AND RESPONSIBILITIES (con't)

14.02 Federal Aid Provisions
14.03 Public Convenience and Safety
14.04 Protection and Preservation of Property
14.05 Air and Water Pollution
14.06 Maintenance of Irrigation Water
14.07 The Engineer and the Law
14.08 Insurance Requirements
14.09 Preservation of Fish and Wildlife Habitat

II-15 PROSECUTION AND PROGRESS

15.00 References
15.01 Assignment or Subletting of the Contract
15.02 Start of Work
15.03 Preconstruction Conferences
15.04 Work Suspension and Resumption
15.05 Limitation of Operations
15.06 Contract Time
15.07 Liquidated Damages
15.08 Certificate of Completion
15.09 Default and Termination of the Contract
15.10 State Law Restricting Bidding

II-16 MEASUREMENT AND PAYMENT

16.00 References
16.01 General
16.02 Pay Quantity Documentation
16.03 Payment for Materials on Hand
16.04 Payment for Excess Material
16.05 Eliminated Items
16.06 Estimates-Progress, Semi-Final and Final
16.07 Acceptance and Final Payment
16.08 HB #42 and HB #436 Agreements

II-17 CONTRACT CHANGES

17.00 References
17.01 General
17.02 Definitions
17.03 Changed Conditions
17.04 Supplemental Agreements
17.05 Change Order, Extra Work Orders and Force Account Records

CONSTRUCTION MANUAL

CHAPTER II

CONTRACT ADMINISTRATION

II-18 CONTRACTOR AND HIGHWAY DEPARTMENT RELATIONS

- 18.00 References
- 18.01 General
- 18.02 Instructions to the Contractor
- 18.03 Labor Compliance

II-19 CONSTRUCTION FORMS, RECORDS AND REPORTS

- 19.01 General
- 19.02 Progress Report
- 19.03 Retention of Records

II-20 UTILITIES

- 20.00 Reference
- 20.01 General
- 20.02 Definitions
- 20.03 Authorization for the Work
- 20.04 Engineers Responsibility
- 20.05 Utility Claims
- 20.06 Utility Work Orders
- 20.07 Salvage
- 20.08 Contract Records

II-21 RECLAMATION OF GRAVEL PITS AND BORROW AREAS

- 21.00 References
- 21.01 General
- 21.02 Reclamation Plans
- 21.03 Review of Reclamation Plans
- 21.04 Proposed Pits Adjacent to Rivers, Streams or Lakes
- 21.05 Changes to the Reclamation Plan
- 21.06 Accomplishing the Pit Reclamation
- 21.07 Pit Release
- 21.08 Reject Piles and Excess Material Piles
- 21.09 Rock Quarries and Rip Rap Sources
- 21.10 Pits Remaining Unreclaimed After Completion of the Gravel or Borrow Operations
- 21.11 Pits Under Administration of Both the Department of Highways and the Department of State Lands
- 21.12 Annual Report of Reclamation Plans

II-10 Definitions & Terms

10.00 References

Standard Specifications, Section 1

10.01 General

The interpretation and use of words and terms in this manual shall be the same as set forth under definition and terms in Section 1 of the Standard Specifications. If conflict occurs between the instructions in this manual and the specifications, the definitions in the specifications shall prevail. The following definitions and terms are supplementary to those contained in Section 1 of the Standard Specifications and are listed here as an aid in interpreting the construction manual.

10.02 Approved

The word approved, in the State Highway contract, means the written consent to use materials, methods, equipment or workmen to satisfactorily complete any phase of the work. Authority to approve is given to the Resident Engineer through appropriate channels by the State Highway Engineer.

10.03 Claim

A claim is a contractor's formal written request for additional compensation for an item of work or objection to assessments or other deductions. A claim may be settled by the District, the Construction Division, or by a hearing of the State Highway Commission.

10.04 Joint Venture

The forces of two or more prequalified, licensed contractors, either individuals, partnerships, or corporations, joined together to construct the highway project is called a joint venture. The purpose of a joint venture may be to increase bidding capacity or to form a construction team for specialization.

10.05 Order of the Engineer

A written instruction issued to the contractor or his authorized representative is considered an order of the engineer.

10.06 Overbreak

Overbreak is the material in rock cuts that is removed outside of the back slope, neat lines, as staked.

10.07 Overhead

Overhead includes all the costs to the contractor for supervision and administration of the contract including all non-productive costs, such as, office expense, salaries of supervisory personnel, operating expenses of automotive equipment used by supervisory personnel, etc.

10.08 Production Cost

Production cost is the cost of a contractor's operation of producing a material or building a structure or portion of roadway exclusive of profit and overhead.

10.09 Right of Access

Right of access is the right of ingress to the highway from abutting land and the right of egress from the highway to abutting land.

10.10 Roadway Prism

The volumn of cut or fill enclosed by planes of the natural ground line, slope lines, and grading plane, as indicated on the cross sections, is known as a roadway prism.

10.11 Shoulders

A shoulder is the outside or inside portion of the traveled roadway for accommodation of stopped vehicles and emergency use.

10.12 Subcontractor

A prequalified, licensed contractor who performs work, as an individual, partnership, joint venture, or corporation, under contract with the prime contractor is known as a subcontractor.

10.13 Substantial Compliance

The words substantial compliance will almost defy any attempts to make a complete, accurate, encompassing definition unless the Standard Specifications establish numerical boundary limits within which each material or work method must lie to be acceptable. Generally, work that substantially complies with the Standard Specifications will in a large part meet or exceed every specification required of that work, but where deviations occur, those deviations are very minor and their frequency of occurrence is small. The indexes of comparison to determine whether or not work or materials substantially complies with specification requirements almost always is the judgment or opinion of the approving engineer, unless rigorous tolerance systems have been previously established in the contracts.

10.14 Tolerance

A tolerance is a specified deviation from planned dimensions, elevations, weights, lengths, etc., and may be expressed as a fraction of a foot, pound, percentage or other qualification. Tolerances establish a range of values which have been calculated to produce an acceptable product. Work that is outside of the specified tolerances is considered unacceptable. An example of tolerance is the minimum and maximum specification limits which have been established to control the gradation of the various aggregate sizes.

10.15 Work

Work shall be understood to mean furnishing all labor, materials, equipment, and other incidentals necessary for successful completion of a project or a particular part of a project, all in accordance with the requirements of the contract.

II-11 Scope of the Work

11.00 References

Standard Specifications, Section 4
Construction Manual, Chapter II, Section II-17

11.01 General

A construction contract provides detailed instructions via the plans, various specifications and standard drawings for proper construction of the project, as envisioned by the state; whereas the nature of the work, as seen by the contractor, may or may not embrace the same intention. Perhaps a material source must be treated with great care in order to produce a specification product, or special scheduling may be required in order to allow removal of an encroaching utility. Those two particulars are only a few of many special details that may have to be observed by the contractor in preparing his bid and performing the construction work. Both the contractor and engineer must be well aware of the particular conditions required and each must pursue his work with full attention to those special conditions. Talk to the contractor. Make sure he knows of each special condition. Be sure his workers are aware of what is required. Too often an engineer will assume the contractor knows and is fully aware of all his duties in performing the work, but when this assumption is wrong, removal of completed or partially completed work may be necessary. Removal is costly. It must be done when necessary but can be easily avoided in cases where the contractor did not know the special requirements. Where doubt or disagreement exists as to the intention of the plans or specifications, the "Engineer" is to provide interpretation or decide questions. The "Engineer" can be the Resident, Division, District or Helena headquarters engineer, or any combination of these. However, interpretation and decision making must begin on the project with the Resident Engineer. Naturally, any help needed to solve special problems should be quickly obtained from those most able to give the aid. The Traffic, Hydraulic, and Road Plans sections of the Preconstruction Division, or the Right of Way, Materials or Construction Division are specialists who can be contacted for assistance but do "go through" the Construction Division to get the needed aid.

When problems arise from ambiguous or apparently conflicting wording or descriptions in the plans and specifications, the contractor's viewpoint as well as the State's should be considered. It is generally understood that the interpretation given to a specification from a contractor's standpoint would be that which a reasonable contractor, exercising the experience, knowledge and judgment in common usage by his trade, would obtain.

A contractor is expected to have average skill and knowledge. He is not expected to possess the very best abilities possible, but neither is he expected to have only a bare minimum of abilities. Interpretations, on this basis, will then presume that a contractor is an average, reasonable man, capable of foreseeing and providing for numerous contingencies as would any other reasonable average contractor.

11.02 Changes

Section 04.02 of the Standard Specifications states that the State Highway Commission reserves the right to make, at any time during the progress of the work, such increases, decreases, changes in quantity or alterations in the detail of construction as it deems necessary to satisfactorily complete the work.

Highway Commission policy does restrict changes to those actually required to complete the work as contemplated at the time the plans, specifications, and special provisions were approved. Acceptable alterations will include any changes necessary for the safe usage of the project by public traffic, corrections required to insure proper functioning of the facility, and revisions arising out of anticipated conditions which affect construction. Some changes may be made for the convenience of the contractor, providing that specifications are followed and any monetary saving is passed to the State via an adjustment in cost.

Proposed changes should be very carefully considered and evaluated from the standpoint of the contractor's completion time when a project is nearing its completion date. Late changes could add considerably to the cost of the work by requiring labor, equipment, and supervisory personnel to be brought back to the project if the contractor had released these for other jobs. It is possible that such late changes could result in the release of a contractor from liquidated damages. Payment and administration for additional or extra work is included under Section II-17 of this manual, Contract Changes.

11.03 Detours and Maintenance of Traffic

The contractor is required by specification to maintain the roadway under construction providing at all times adequate and safe passage for the traveling public. Occasionally the contractor will be unable to provide for continuous passage of the traffic through the project because of blasting or various operations that occur from time to time. Notify the Construction Division before the delay occurs and state the duration, causes and where the delay will be. It is good to know of possible alternate routes that through traffic can take in case of emergency. Notice will be given to the local newspapers, radio or television stations so that traffic can be alerted of various delays throughout the construction project.

The contractor is not required to remove snow from streets, intersections, parking lots, residences, garages, and various other approaches to the construction project. However, he is responsible to keep such approaches open to those persons involved in using them. Any expense involved in maintaining traffic over a section of road will be entirely the contractors, except where items are in the contract for maintenance of detours, removing existing structures, and maintaining traffic. In such cases payment may be made under the contract item for the various work involved.

Should any difficulties arise between the resident engineer and the contractor's superintendent on what constitutes sufficient construction signing or proper maintenance of detours, the controversy should be settled on the job if at all possible. When this has been tried unsuccessfully, refer to the Division Engineer. He will attempt to make his decision based on his own interpretation of the facts, but also considering past accident experience of similar situations, adequate safety and traffic control measures. Please consult the Construction Division if there is any doubt or if a decision cannot be reached.

A contractor who intends to detour traffic in any manner other than that specified in the contract or on the plans must be guided by the following details, and must have had these details discussed with the Division Engineer and with the Construction Engineer when the problems are more than routine.

1. Route shown on sketch map.
2. Number and location of flagmen to be used.
3. Proposed type and intended care of roadway surface.
4. Type and location of signs to be used.
5. Reason for detouring the traffic.

The subject of detours, traffic safety through construction areas, construction signing, and similar subjects should be thoroughly discussed at the preconstruction conference in order that there be no doubt in the contractor's mind about the State Highway Commission's intentions of providing safe construction zones for the traveling public. We do not want any road closures if at all preventable. When necessary road closures or detours are intended to be put into operation, a notification shall be made by letter or telegram to the Construction Division office stating the exact date and the approximate time and length that the construction project will be closed to traffic and when the detour will be put into use. The same procedure of notification must be used in the case of special detours as shown on the plans. Written notification is usually unnecessary when traffic is bypassed around a structure or other work for comparatively short distances (a few hundred feet) and short periods of time (a few minutes).

Emergency conditions (washouts, impassable roads caused by flooding, land slides, etc.) on the project may require the Resident Engineer to authorize the closure of a construction project to traffic for the protection of life and property without giving prior notice of such closure to the Division Engineer. When such urgent and emergency conditions prevail, the Resident Engineer should contact the Division Engineer as soon as possible.

Should emergency or other conditions warrant closing roads that are not under the jurisdiction or owned by the State Highway Commission, the owners of such roads are to be immediately notified of our intentions and given the pertinent details by the Division Engineer. On Forest highways the local ranger should be advised. National Park roads or parkways shall not be closed without first discussing the matter with the park or parkway superintendent. Notification of closing local roads should also be given to the local law enforcement officers.

If a highway is closed without prior warning to the public, the contractor must place men at each barricade to advise the traveling public that the road is closed, why it has been closed, the approximate length of time the highway will be closed, and what detour they can use to best reach their desired destination.

In case a detour crosses a railroad the contractor shall make the necessary arrangement with the railroad company and secure the necessary permission.

Detours and temporary roads should be of adequate width and surfacing depth to accommodate the vehicles using them. They should be two-way roads, where possible, and may require a design from the Helena headquarters to assure maximum usability during service within economic limits.

11.04 Use of Materials Found in the Work

Authorization for excavation outside planned slope and grade lines may be made but must be justified as a benefit to the state rather than for the contractor's convenience. Such authorization should in no way adversely affect the appearance or function of the planned project and can be given only under written authority.

The contractor may use materials found on the job that meet the applicable requirements of the specifications. The contractor should not be allowed to exchange materials so that one material would overrun the contract quantity and another material would underrun, causing a net benefit to the contractor. All usable materials should be excavated within the roadway prism to grade lines. Then if additional materials are necessary to complete balances, to complete grades, the contractor may be allowed to obtain borrow from other sources. The Resident Engineer should guard against allowing double payment for work accomplished on materials found within the work.

Should acceptable materials be found within the work which can be used for aggregate surfacing or similar items, the contractor may be allowed to use these materials under certain circumstances. However, this practice is not always desirable from the standpoint of possibly paying the royalty on the previously intended materials source, changes the haul distance originally planned, possible improper location of other borrow or waste areas that were not planned. Too many projects have exceptionally steep side slopes or wide ditches caused by contractors using unclassified excavation material for purposes other than planned and then making up the deficiency from roadside sources. Approval must be gained before any use of materials can be made that is contrary to the planned use.

II-12 CONTROL OF WORK

12.00 References

Standard Specifications: Section 5

12.01 Authority of the Engineer

Authority is the power or right to give commands, to take action. The Department of Highways has been granted authority by the State of Montana to issue various road construction contracts and to carry on the general highway work. The authority of the Department of Highways has been passed on to the Project Manager through channels so that he may properly control construction contracts assigned to him. His authority and ability to control the work is derived through the contract, plans, specifications, and various documents. Attempts by the Project Manager to act outside the authority granted through specifications and various other contract documents will not be condoned. The Project Manager is the chief inspector on the construction contracts assigned to him. He will, within his ability, decide all questions which may arise as to the quality and acceptability of materials, and work performed, and questions of interpretations of the plans and specifications. He will have authority to suspend any work which fails to comply with the contract requirements. It is important that the Project Manager makes no unauthorized commitments by representations, promises, demands or instructions, verbally or by written memorandum that will be outside the scope of the plans, specifications, and special provisions. In case of doubt as to his authority he should consult the Division Construction Supervisor.

The Project Manager does not have the authority to direct the contractors operations except under very special and very unusual circumstances and only then with complete understanding between the State, the contractor, and the contractor's surety.

The Project Manager is expected to make suggestions and assist the contractor in ways that are consistent with his responsibilities and authority in inspecting or approving the work under contract. One way to aid a contractor is to alert him that his method of work, if poor, should be discontinued and tell him why. Usually a contractor who selects a poor method of operation will no doubt produce work that is sub-standard in quality or work that will not meet the specification requirements. Methods that produce non-specification work should be stopped to save the contractor the time and money of repair or replacement.

Sometimes the Division Construction Supervisor can be a great help in gaining and holding the contractor's cooperation when a poor work method needs to be changed, but the contractor is balky about making the change. Here the teamwork of the Division Construction

Supervisor and the Project Manager can generate a firmness the contractor will respect, but still maintain a good working arrangement.

Important verbal and written orders are given to the contractor and received from him during the course of the project, but frequently a verbal order will need written confirmation. So to help the Project Manager know what orders should be written and what section of the specification book contains instructions about the order, the following list of "Written Orders to and from the Contractor" has been compiled. This list is not the last word, nor does it set out the only circumstances that may occur.

WRITTEN ORDERS TO AND FROM THE CONTRACTOR

	SUBJECT	SECTION OF SPECIFICATIONS
Contract Administration		
1.	Various portions of Bidding Requirements and Award and Execution	2 & 3
2.	Contractor says project is complete, Contractor starts a claim, name of Superintendent	05.15 05.16 05.05
3.	Deduction from estimate for landowners backpay on Materials	06.01
4.	Contractor to tell of conflict with any law, all insurance requirements close Public Roads	07.01 07.13 07.07
5.	Notice to proceed, Suspend and Resume Orders	08.02 08.03
6.	Contractor wants more time, wants semi-final estimate	08.06 09.06
7.	Assignment of more than 50% of earnings, subcontracting, consent of surety	08.01(A) 08.01(B)
8.	Neglect or default in contract terms, Termination of contract, Certificate of Completion	08.08 05.15
9.	Notice of any claim against contract and bond, Release by State agency having claim	09.08

10.	Surety's permission to pay final estimate, wants release of retainage	09.08
11.	Contractor requests payment for Materials on hand	09.07
12.	Contractor files written compliant when apparent error, omission, etc. is discovered	05.08

Contract Changes

1.	Increases or decreases in quantities, changes in planned construction details	04.02
2.	Elimination of proposed work or contract items, changes in dimensions of concrete pavement	09.05 09.01
3.	Changes in method of measurement, Prior approval before doing extra work	09.01 09.04(B), 04.03
4.	Changes in the elevation of the bottom of structure footings, structural changes	41.04(B) 41.01
5.	Changes in excavation lines and grades of culverts	52.02

Contractors Equipment

1.	Contractor wants to use equipment on rental basis	08.01(C)
2.	Engineers request to remove workmen; contractors equipment to use non-contractual equipment or methods; contractor rental of publicly-owned equipment	08.05
3.	Notice of State intentions to assume contractors Forces	08.08
4.	Permission to operate concrete mixer in excess of rated capacity	39.04(E)
5.	Alternate methods of loading batched aggregates and Cement	39.04(F)
6.	Permission to use transit-mixed concrete or central mixing plant	39.04(F)

Control of Work

1.	Permission to excavate beyond staked limits	04.05
2.	Engineers directives to contractor to perform uncompleted final cleanup	04.04(F)
3.	Directions to correct unsafe working conditions	05.01
4.	Inform engineer of contractors superintendent's name	05.05
5.	Notices for correction of unacceptable work (Progress & Final)	05.12
6.	Roadway maintenance and construction protection	05.14 & 04.04(C)
7.	Notification of blasting to Utility Companies	07.10
8.	Owners permission for shutting off irrigation water	04.04(D)
9.	Notification by contractor for (a) Permission to perform night work (b) Suspension or resumption of work (c) Suspending work without permission	08.03
10.	Permission to exceed two miles limit of roadway under construction	08.04
11.	Notice to contractor of delay in work	08.08
12.	Landowners permission to dispose of debris on their property. Permission to cut National Forest timber.	10.02(E)(2) 10.02(B)
13.	Permits to burn grubbing debris	10.02(E)(1)
14.	For contractors request to use salvageable materials	10.32
15.	Permission to broadcast seeds	17.13(C)(3)
16.	To change limitations on plant mixing dates	30.05(A)
17.	To change limitations on Bituminous Treatment dates	32.04(F)
18.	Contractor to furnish reclamation plan	06.02(E)
19.	Contractor to furnish proposal describing disposal areas	10.02(A)

Rev.5-1-73

20.	To change limitations on road mixing dates	33.05(A)(1)
21.	To change limitations on seal coat dates	34.04(A)
22.	Prior approval to use curing membrane	40.05(E)(2)(a)
23.	Changes in structure work	41.01
24.	Detail drawings of falsework to engineer	41.04(C)
25.	Approval to place concrete under water	41.04(F)
26.	Permission from engineer to remove falsework	41.04(K)
27.	Permission to deviate from approved Fabrication Plans	42.03 & 43.03
28.	Notice to begin steel fabrication	43.05(A)
29.	Permission to revise spacing of timber stringers	44.05(J)
30.	Permission to leave timber bracing from cribs or coffer dams in substructure masonry	45.03(C)
31.	State approval of traffic signal and lighting details	87.04
32.	State approval to abandon "in place" electrical equipment	87.09(A)
33.	Permission to extend painting dates	91.06(B)(4)

Control of Material

1.	Contractors' notice of selecting source for various materials, Approval of materials via test reports, certificates, etc.	06.03
2.	Permission to store materials on private property	06.06
3.	Permission for contractor to use materials having salvagable value	10.32(A)(4)(d)
4.	Change in brand and type of cement	40.04(A)(1)(b)
5.	Permission to use water or current reducing additives	40.04(A)(3)

6.	Permission to hand mix concrete in emergencies	40.05(C)(2)
7.	Permission to use admixtures	42.04(A)
8.	Permission to substitute bolts	43.06(G)(1)
9.	Permission to remove intermediate sized aggregates from those produced	M-100.07(5)
10.	Permission to use ready-mixed cold applied joint fillers	M-150.01(A)(2)

Request for Payment

1.	Payment for increase in freight rates	09.025
2.	Payment for materials on hand	09.07
3.	Payment for excess materials	09.09

12.02 Contractor's Equipment, Personnel, and Operation

A contractor has usually based his bid on using certain equipment, most of which he has used on previous work and which he thinks will do the job better or even less expensively. It should be remembered that choice of equipment is the contractor's responsibility and prerogative as long as it performs work which can be accepted under the specifications.

The Project Manager shall satisfy himself by inspection that the contractor's plant, equipment and tools will produce work that complies with the specifications. The contractor should not be allowed to start work unless his equipment is adequate for the proposed use, and it must be maintained in good workable condition. Other portions of this manual deal with the actual inspection and details involved in inspecting the contractor's equipment, plant, and method of operation.

It is essential that the contractor's supervisory personnel be competent, experienced and able to properly execute the work in order that the specifications and plans will be strictly adhered to. When the contractor's supervisory personnel are not competent, it is the duty of the Project Manager to report this condition to the Division Construction Supervisor. Incompetent, careless, or negligent employees or agents of the contractor shall be discharged by the contractor upon written request from the Project Manager.

12.03 Approval of Subcontractors

Each subcontractor intending to do work for the prime contractor must have been prequalified through the Construction Bureau. The Project Manager should assure himself that the subcontract has been previously approved and an approved copy is in his file or on the way. Although the Department of Highways did not sign the original contract for the construction project with the subcontractor, the subcontractor must comply with all rules and regulations, specifications, plans, and special provisions as if he were actually the prime contractor. All notification, written memorandums etc., that deal with the orders from the engineer to the subcontractor shall be directed through the prime contractor.

12.04 Lines and Grades

On rare occasion a contractor unfamiliar with the Department of Highways method of constructing and surveying roads will attempt to do his own surveying. This is contrary to the contract and specifications. The Department of Highways survey crews are responsible for setting construction stakes, establishing lines, slopes, continuous profile grade and all such construction survey needs. The Project Manager will furnish the contractor with all necessary information relating to the lines, slopes and grades. The contractor is then responsible for preserving the stakes and marks that have been set. The cost of replacement resulting from continual, willful or careless destruction by the contractor of these lines and grades can be deducted from the cost of the work that he has performed, and in some exceptional instances this may be the only way to bring the contractor's attention to his willful disregard for the lines, slopes, and grade stakes that have been set. The subject of preserving the construction stakes that have been set should be thoroughly discussed in the pre-construction conference where the contractor can be informed of the cost of the work of replacing these stakes and the possible delay to his forces that may occur because of the necessary resurveying work that is to be done. In any construction work the occasional destruction of a few stakes is almost impossible to prevent. The Project Manager should not become exceptionally fussy or overly technical at having to replace a very few stakes.

12.05 Inspection

The Department of Highways wants to open each job up to the traveling public as rapidly as it possibly can. It wants each project completed on time if at all possible, but in order that there be no misunderstanding of which is more important--opening the project to traffic or requiring specification construction--comply with the specification first. If a situation arises where you must choose between accepting work which is substandard in order to facilitate meeting a progress schedule or opening to traffic on a certain date, there is only one decision that can be made, and that is the work must measure up to our specifications.

Sections 05.09, 05.10, and 05.11 in the Standard Specifications for Road and Bridge Construction, under the general heading of "Control of the Work" state very clearly the authority of the engineer and inspector relative to questions which may arise during construction of a project. This is the authority that is granted by contract. Should the engineer exercise authority that is outside the scope of that described under the previously mentioned sections, he is operating on shaky ground and may require the contractor to perform work for which he can not be made responsible. The Project Manager should assist the contractor in ways that are consistent with his responsibility and authority. However, whenever any assistance is given to the contractor, it is important that the Project Manager make no unauthorized commitments, promises, demands, or instructions, either verbally or in writing that will be outside the scope of the plans, specifications and special provisions. Similarly when the contractor's employees elect to disregard directives of the engineer or orders in the specifications or special provisions and proceed on their own initiative, to follow procedures which are not in accordance with proper work, they assume the risk of rejection of the work after it has been completed.

Work items which do not meet specification requirements, do not conform to the directions on the plans or the special provisions or are placed contrary to the engineer's verbal or written instructions, will be removed and replaced at the sole expense of the contractor. Should the engineer wish to invoke Section 08.05, Character of Workmen; Methods and Equipment, in requesting the discharge of contractor's employees who willfully and continuously act contrary to the engineer's instructions or otherwise conduct themselves in an improper manner, he should first discuss this severe action with the contractor's superintendent and with his Division Construction Supervisor, document the discussions and then issue the written instruction to the contractor for the dismissal of the employee or employees involved.

12.06 Rejection of Defective or Unauthorized Work

Deficiencies in the quality of work, when observed by the Project Manager or his inspectors, should never be allowed to continue. Unacceptable work should be removed, replaced or corrected. The inspector should call the deficiency to the attention of the foreman or superintendent in charge of the work. Where the superintendent or foreman are not available, another contractor's employee should be authorized to act for that superintendent or foreman. The Project Manager should ask the contractor's superintendent who he will put in charge of the work in case of his absence. Regardless of whether the work underway is of minor significance or of major importance a representative of the contractor must be in charge. This delegation of authority will contribute to better contractor-engineer relationships. It provides for a direct line of communication between the inspector, and the contractor personnel performing the work. With this line of communication the inspector can discuss the work and deficiencies without having to chase through the whole project in an attempt to find an absent superintendent.

Section 05.12 of the Standard Specifications for Road and Bridge Construction specifically describes the engineer's authority in removal of unacceptable and unauthorized work. The inspector should avoid giving specific instructions as to the operation or adjustment of equipment, the use of various construction methods, etc. Should such instructions be given and the quality of the work become deficient, the engineer can then be held responsible for the outcome of that work. If deficiencies are pointed out to the contractor's responsible representative and are not corrected promptly or assurance is not given that corrective action will be initiated, the inspector should take the matter up with the Project Manager and the contractor's superintendent. If necessary the Project Manager should issue an order instructing the contractor in writing of the corrective action necessary to bring the deficient work items up to an acceptable standard. Before issuing instructions to correct defective work the inspector should be sure that his judgment is sound and fair. The decision should then be firmly supported without personal arguments.

12.07 Claims for Adjustment and Disputes

The contractor is requested to notify the engineer in writing when he feels that additional compensation is due him for work or material not clearly covered in the contract or not ordered by the engineer as extra work. This written notification will declare the contractor's intention to make a claim for such additional compensation. The written notice must be received before the contractor begins work on which he bases the claim; otherwise, the basis for the claim may not be allowed at a future date, because if the engineer isn't afforded proper facilities by the contractor for keeping strict count of the actual cost as required, a mutual basis for determining the proper value of the claim will not exist. Claims of this nature are usually described and controlled through force account work. Costs and claims are much easier to handle if taken care of before rather than after the work is done.

12.08 Post Grading Inspections on Interstate Projects

Post grading inspections should be conducted on each Interstate project just prior to completion of grading operations and the start of surfacing operations. The post grading inspection should be held before earth moving equipment has been moved off the project in case changes in grading, slope flattening, etc., are required. The Division Construction Supervisor will notify the Construction Bureau sufficiently in advance, when a project is ready for post grading inspection so that the Construction Bureau can make arrangements for the inspection.

The personnel that should attend a post grading inspection are the Division Construction Supervisor, the Project Manager, the FHWA Area Engineer, a representative from the Construction Bureau, representatives from the Pre-Construction Bureau and the Division Maintenance Supervisor.

The post grading inspection report will be prepared by the representative of the Construction Bureau.

12.09 Pre-Completion Inspection of Interstate Projects

The purpose of this inspection is to provide a final check of the features being constructed at a time when desirable corrections, changes, additions or deletions may be initiated and instituted and before the contractor has finished his work and removed his men and equipment from the site.

Items which should be inspected are:

1. Safety hazards which have been inadvertently built into the new work.
2. Maintenance problems which can be corrected before the project is accepted such as potential erosion areas, Bridge End settlements, Stockpass and Vehicular Underpass inlet and outlet ends and other general drainage features.
3. Incorrect signing which should be corrected before the project is opened to the public.
4. General clean-up of the projects should be discussed.
5. Borrow and Gravel Pit Reclamation.
6. Two to four lane transitions at the ends of the project.
7. Other potential problem areas noticed during the inspection.

The Pre-Completion review team may be composed of the following members: Supervisor of the Division Construction Section, Manager of the Field Project Unit, Administrator-Maintenance Division, Chief-Field Maintenance Bureau, FHWA District Engineer, Pre-Construction Section and Construction Bureau.

It will be the responsibility of the Supervisor of the Division Construction Section to notify the Construction Bureau sufficiently in advance of project completion so that the inspection can be planned for and conducted during the final stages of the plant mix operation. This timing is needed so that corrections and adjustments disclosed during the inspection can be completed before the plant is moved out. It is suggested this notice to the Construction Bureau be initiated several weeks in advance so the review team can properly plan their trip.

12.10 Final Inspection

When the project is substantially completed, the contractor may request a final inspection. If the Project Manager feels the contract is substantially completed, he will arrange a final inspection through

The Division Construction Supervisor. The Division Construction Supervisor will notify the FHWA Area Engineer and set the date for the final inspection. However, if the Project Manager doesn't believe the job is substantially completed he should develop a check list of any uncompleted work. The items on the check list should be specific as to location and nature of the uncompleted work. The contractor's representative should then have a clear understanding of what work is necessary as shown on that check list. When the items on the check list have been completed to the satisfaction of the Project Manager, he should then contact the Division Construction Supervisor and arrange for the final inspection that had been previously requested by the contractor.

A certificate of completion will be made out for the completed project. See Article 15.08 and Figure II-4.

II-13 Control of Materials

13.00 References

Standard Specifications, Sections 06, M100, M200 and M300

13.01 Contractor's Responsibilities

The contractor must submit a list of his sources of supply for materials to be used in the work. The list must be submitted to the Materials Engineer in time to make proper arrangements for early inspection and testing of the material so listed. Materials which do not comply with specifications must be rejected and the contractor notified at the earliest opportunity so that he may arrange to obtain materials from other sources.

Manufactured materials are tested and inspected at the source of supply, whenever this is practical. When materials are manufactured outside of the State of Montana, testing and inspection is handled under contracts with nation-wide testing laboratories such as Hunt Testing Labs, Pittsburgh Testing Labs, etc. The Helena Laboratory is in charge and responsible for arranging for all such testing. Correspondence regarding materials to be tested by outside agencies is to be directed to the Materials Engineer, Helena. State Highway Commission inspectors or contracting testing agencies who are representatives of the State will have free entry at all times to those parts of plants which are engaged in the manufacture or production of materials for State work. Authority to use materials tested by nation-wide labs or by State Highway inspectors from the Helena Materials Division is received by the Resident Engineer through the Materials Division. Generally these reports will reach the Resident Engineer prior to receiving the material on the job site. No material should be used in the work until the Resident Engineer has received the reports and has reinspected the materials. However, the responsibility for incorporating adequate and satisfactory materials into the work rests entirely with the contractor. Frequently materials fabricated outside the State have been adequately tested, are correct and proper to use, and have been received on the job; however, the materials test report is not available to the Resident Engineer. In such cases when notification has been given; a certificate, memo, or teletype may be prepared to alert the Resident Engineer that a test report has been received in the Helena Office and is on its way, that the materials are proper and may be installed, subject, of course, to the field approval.

The contractor is responsible to furnish materials lists, manufacturer's brochures, shop drawings and other necessary documents that certify to a materials' acceptability, especially in the case of standard manufactured products. All products intending to be installed in a highway project must have been approved by the Resident Engineer or other engineers responsible for their approval. This requires that the Resident Engineer place in his files copies of all approved materials lists, manufacturer's brochures, shop drawings, on-sight inspections for dimension and visible checks of materials used, and other such necessary certificates that will prove the materials used have truly been inspected and approved.

The contractor is responsible for State furnished material stored or used by him and shall make good any damage or replace any stolen material. Storage sites or buildings are to be inspected and deficiencies corrected before use.

The specifications or special provisions many time will use a trade name (or equal) to designate required products. The contractor then has the option of furnishing alternate articles or materials which are of equal or better quality to that which is specified. The burden of prood that the quality and suitability of the chosen alternate is equal to or better is entirely up to the contractor. Any information required or necessary to determine its suitability must be furnished by the contractor to the Resident Engineer. These requests for substitution must be submitted to the Construction Engineer and received in time to permit approval and inspection without delay of the work.

Occasionally various materials required by specification will not be available through the usual sources of supply, thus causing a delay or an impending delay to the contractor.

On defense projects, it is the contractor's responsibility to furnish letters from various suppliers stating that the materials required are unavailable at the present time. These letters are necessary in order that a time extension may be allowed to the contractor due to a delay in his work caused by material shortages.

13.02 Use of Locally Available Materials

Materials used to construct the structural section immediately below the pavement may be obtained from locally available sources, as follows:

1. Sources selected by the contractor.
2. Sources indicated by the Commission.
3. Mandatory sources designated by the Commission.

The above sources may include materials for aggregate surfacing, selected surfacing, or similar gravel materials from pits or rock quarries.

Excavation of material from any local material source will remain under the direction of the engineer at all times insofar as the selection of material or the exact location of the excavation is involved. This requirement is to assure that material is excavated at the site in a manner which will produce unifrm material conforming to the specifications. Although the contractor shall bear the complete expense of acquisition, development, production and incorporation of materils into the roadway from sources selected by him or those sources indicated by the Commission, it remains the Resident Engineer's responsibility to approve the corporation of those materials into the roadway. It has been Highway Commission policy to provide informational testing services to the Contractor while he is producing materials from sources selected by him or those indicated by the Commission. When the results of such testing indicate that the materials are not meeting the specification requirements, the engineer should inform the contractor of this and make proper notes in his diary and in the test reports. Frequently a contractor will say, "This material belongs to me and I will produce it as I see fit", regardless of what the engineer's test reports will state. Occasionally such improperly produced materials will meet specifications after other screening has occurred, but more often these improperly produced materials will not meet specifications at a later date and therefore the proper documentation of directions and information given to the contractor to adjust his methods can be invaluable. The engineer should make written notations describing the deficiencies to the contractor while the materials are being produced.

The Highway Commission may indicate two or more sources from which materials of acceptable quality are understood to be available. The right to decide the order of sequence and extent to which each source shall be used remains with the Commission.

13.03 Materials Acceptance or Rejection

Materials may be stored to preserve their quality and fitness on approved storage sites. Materials should be inspected as they are stored and may again be inspected prior to their removal from the storage site and incorporation into work. The engineers should not assume that previously approved materials will remain acceptable throughout their time in a storage site. Occasionally various aggregates will break down under prolonged period of weathering. Metals may rust. Other materials may be contaminated by water or air pollutants. It is therefore good project management to briefly inspect any materials that may be suspected of not being acceptable prior to their use.

The engineer may retest any materials prior to their incorporation into the work which may have been previously tested and accepted at any source of supply.

The engineer should avoid any unreasonable practices in retesting materials.

The engineer and inspectors under his direction should frequently consult the Montana Test Methods Manual for the proper test to use in accepting or rejecting materials. The majority of materials tests involve a standardized process accepted throughout the nation by various testing agencies ---AASHO, or ASTM. Therefore, the majority of materials tested, accepted or rejected, will have an authorized test report to verify the acceptance or rejection. Occasionally an obvious flaw or defect may be observed by the inspector and called to the attention of the contractor's representative. The contractor may not see the defect as the inspector does. When such cases exist, the inspector should provide a test to disclose the defect. Then his rejection of the material has a valid basis. Where mutual agreement between the inspector and the contractor's representative as to flaws or defects exist, then test records may not be absolutely essential, because the contractor will fully intend to correct those defects pointed out to him. However, the inspector should make the proper notation in his diary and inform the engineer of the discussion and defects found and corrective action taken.

II-14 Legal Relations and Responsibilities

14.00 References

Standard Specifications - Section 7

14.01 Laws To Be Observed

It is assumed that the contractor is fully informed of all Federal, State and local laws and it shall be the duty of the Resident Engineer to assure himself that the contractor is abiding by all of the laws under which his work shall fall. Any violation of Federal, State or local law shall be brought to the attention of the contractor by the engineer in the form of a written memorandum. Copies of this memorandum should be sent through the Division Engineer. The time worn words "ignorance of the Law is no excuse" has been made a part of the construction contract; however, should any provision in the contract appear contrary or inconsistent with any Federal, State or local law the apparent inconsistency shall be brought to the attention of the State Highway Commission. The Revised Codes of Montana and amendments thereto generally govern legal activities within the confines of the State of Montana and will apply to the contractor in his relations with the State Highway Commission. One portion of the Revised Codes of Montana deals with allowing preference to honorably discharged personnel of the armed forces of the United States and to disabled civilians. Any apparent discrimination in hiring practices that is observed by the Resident Engineer should be brought to the attention of the office of the Labor Coordinator-Economist, Construction Division, Helena. The memorandum should contain all pertinent facts and details in accordance with good memorandum writing procedure.

Any person who is gainfully employed in Montana is required by law to purchase Montana license plates for his vehicle. This applies equally well to contractor's personnel and to the equipment of the contractor himself. Violators must be immediately reported to the local Highway Patrolman. If no action is taken, then notify the Construction Office, Helena. The Revised Codes of Montana, 1947, 53-119 through 53-129, cover with the licensing of motor vehicles operated on Montana construction projects and in the State of Montana.

Any work performed by the contractor in which he uses patented devices, designs, or materials or processes in which claims of infringement have occurred shall hold the State harmless from any costs, expenses, or damages by reason of the alleged infringement. The Resident Engineer will assure himself that the contractor is not infringing on any copyrights or patents, but where an apparent infringement exists, the engineer shall discuss the discrepancy with the contractor in an attempt to resolve the difficulty and establish the basis for refuting any future claims the contractor may have or may involve the State with as far as patent infringements are concerned.

14.02 Federal Aid Provisions

Although the Federal government is not a party to the contract between a contractor and the State Highway Commission of Montana involving the use of federal funds, the work shall be subject to the inspection of the appropriate federal agency, usually the Bureau of Public Roads' engineers. However, inspection by this federal agency shall in no sense make the federal government a party to the contract and should in no way interfer with the rights of either party. The Resident Engineer should accompany any Bureau of Public Roads engineer who is on the project for the purpose of inspecting any phase of the work. Any discussions, decisions, or deficiencies found by the Bureau of Public Roads' should be listed in the Resident Engineer's diary.

14.03 Public Convenience and Safety

The Resident Engineer is responsible to see that the contractor is at all times conducting his work to assure the least possible obstruction to traffic. Construction signing standards have previously been drafted to allow sufficient payment to the contractor for placing barricades, making detours, putting up the proper construction signs in an attempt to make the construction areas passable and safe to the motoring public. No roads shall be closed to the public except by the expressed permission of the engineer. The Resident engineer should never allow a contractor to close or deny access to a road without first consulting with him.

Federal aid relates to participation by the Federal government in the administration and financing of highway construction projects on the Federal system of highways.

Federal financing in the usual sense is applied to Interstate routes, Federal aid primary, secondary and urban routes. Included in the special provisions for Interstate and Federal aid Primary projects are separate sections designated as Federal requirements for Interstate highway projects and Federal requirements, respectively. The principal difference between the two specifications is the requirement pertaining to the submission of contractors' payrolls.

The engineer should become familiar with the section applicable to his project and see that all regulations are followed implicitly.

Federal aid Secondary projects are generally on county routes, but also may be on State highway routes in the Federal secondary system. In either case the contracts are State Highway contracts and are subject to the same conditions as all State Highway contracts.

The Resident Engineer must see that all provisions of the special provisions relating to Federal requirements are properly carried out. Posting of wage rates by the contractor and spot checking of wages paid, by interviewing different employees of the contractor, are a few of the details required during construction inspection on Interstate projects.

Any changes that become necessary during the course of construction should be discussed and reviewed with the Area Engineer of the Bureau of Public Roads before issuing a change order. Federal participation in any change may be jeopardized if the Area Engineer of the Bureau is not conversant with the proposed change. If it is not possible due to time restriction to discuss the change with the Bureau of Public Roads' representatives, then this should be fully covered in the letter of transmittal accompanying the contract's change order.

Procurement of a new material may be necessary to complete the roadway construction. Federal regulations relative to participation in procuring materials are very explicit and the engineer must be sure that he is not jeopardizing this participation by designating improper material sites.

The Resident engineer can greatly aid the conduct of traffic through the construction area, the safety and convenience of those property owners adjoining the construction site, by making preliminary contact with the various land owners involved. The Resident Engineer can determine by these initial contacts what may become a future inconvenience to any particular property owner. He should discuss the property owner's rights and convenience with the contractor, making the contractor aware that he should conduct his construction activities in such a manner that no inconvenience will result, or at least any inconveniences will be minimized and each individual property owner will then have been accorded the benefit of having a voice in how construction will affect his individual property.

Occasionally motorists will have accidents on the construction site. When these accidents result in injuries to the motorist, his property, or contractor's property, law suits often times develop. These law suits come to trial usually a few years after the occurance of the accident. It is, therefore, mandatory that should any accident occur on any Montana construction project, the Resident Engineer shall make a full report of the facts involved, weather conditions, signing on the project, signing leading to the project, posting of restrictive speed limit signs, and the general condition of the traveled way. He should list the various hazards that may be involved, and whether these hazards had forewarning. This report should remain in his files and should be then submitted to the Division Engineer with a copy to the Construction Engineer in Helena. The majority of accidents can be prevented by adequate construction signing and hazard warning. It is sometimes almost impossible to provide sufficient signs and warning devices for the one exceptional motorist.

14.04 Protection And Preservation Of Property

The contractor is responsible for all damage or injury to property during the prosecution of the construction project. The contractor is to restore at his own expense any public or private property that has become damaged through the acts of omission, neglect, or misconduct of the contractor. The construction contract will not have been considered completed until all such damage has been satisfactorily restored. It is the duty of the Resident Engineer to properly record the dates, times,& various events involved where property damage has occurred. Although it is the contractor's responsibility to contact the owners involved, it is also the Resident Engineer's responsibility to see that proper restoration has been made.

Work occurring adjacent to or within the boundaries of the State or National Forest must be performed in accordance with the rules of the authority having jurisdiction. The Resident Engineer and the contractor's representative should meet with the supervisor of the forest or that individual having charge of the forest and discuss the various mode of conduct, schedule of operations, laws to be observed and sanitary provisions for the contractors and state forces involved. Various permits may be necessary to conduct clearing and burning operations. Obtaining these permits is the duty of the contractor, but the Resident Engineer should have in his files copies of these various permits that are necessary. The location of storage areas, disposal areas, warehouses, construction camps, and various other structures should be discussed with the forest supervisor and adequate provisions made. The Resident Engineer should record in his diary all various discussions dealing with protection of forest property.

Local laws or ordinances usually apply to the storage of explosive and the use of explosives. The Resident Engineer together with the contractor should review the various storage site possibilities and the engineer finally approve a storage site that is satisfactory from the standpoint of possible damage to public or private property, to the individual workers in the area, and which abides by local laws or ordinances. In general, the storage for explosives should never be closer than 1000 feet from any road or from any building, camping area, or place of human occupancy. The engineer should discuss the use of explosives on the construction project assuring himself that the contractor is well aware of the hazards involved and that before any shot is allowed to occur all persons within the radius of danger have had adequate warning and have been alerted as to when the specific moment of firing will occur. Copies of notices given to public utility companies owning property in the proximity of the explosive work shall have been given to the Resident Engineer and incorporated into his files. Such notices shall have been given sufficiently in advance of the explosions to enable the companies to take any precautionary measures they deem necessary.

In signing the original construction contract the contractor has agreed to accept full responsibility for the work of the contract from the day of award until the final date of acceptance and completion by the Highway Commission and the Bureau of Public Roads. During this interval of time the Resident Engineer shall check on all of the contractor's operations, assuring that precautions against injury or damage to various property, assuring that the contractor has restored, rebuilt or repaired or made good any and all injuries done to any portion of public or private property or to the work involved. The contractor is responsible to protect the project at all times from damage due to weather conditions or to adverse conditions during any period of suspension of work. The Resident Engineer should discuss the various contract responsibilities with the contractor during the preconstruction conference and at other frequent intervals as deemed necessary throughout the course of construction.

14.05 Air and Water Pollution

The engineer should acquaint himself with all local, city, county or state laws pertaining to air and water pollution before allowing any operations that may introduce contaminates into the water or atmosphere. Should legal action be instituted against the contractor forcing him to conduct his operation in a dust and smoke free manner, the Resident Engineer will be called upon to defend the reasons why he did not request the contractor to operate according to the ordinances or laws involved. It is assumed that adequate dust filters, smoke collectors, or other means may be required to limit the amount of pollutants and therefore no additional payment could be made to the contractor for installation of such equipment. Requests for reimbursement where these conditions are encountered should be disallowed by the Resident Engineer.

Montana has some of the most beautiful and famous fishing streams found in the nation. To pollute these during the course of construction would be classified as sacrilege and furthermore may be in direct violation with various state laws involving the use and contaminating or pollution of streams and water courses in the State of Montana. The contractor must be acquainted with the various laws involved. The engineer in turn must also acquaint himself with the special provisions involving contamination of streams and with the State laws involving air and water pollution. The Fish and Game Commission should be contacted when there is any doubt in either the engineer's or the contractor's mind as to how to perform operations that may endanger the fish habitat. Fish and Game officials should be invited to the preconstruction conference involving work near water courses, where the various schedules, methods of operations, equipment usage, and areas to be constructed can be discussed openly in the meeting and decisions made to minimize stream pollution.

The contractor must provide and maintain neat sanitary conditions and such accommodations for the use of his employees as may be necessary to comply with the requirements of the state and local Boards of Health. Although outhouse inspection does not rank high among the honors of the engineering profession, it is surely one of the more important duties of the inspector or the engineer involving air and water pollution.

Permits are required for water pollution. Montana laws regarding water pollution require the issuance of a permit by the State Board of Health, before anyone is allowed to discharge waste water to a surface drainage.

Two conditions associated with highway and bridge construction, which may create waste water are:

1. Washing gravel.

2. Discharging the effluent from a "wet Scrubber" on a dust collection unit.

The first item is minor, since very little aggregate is being washed, but if a contractor washes aggregate for concrete or for other uses, a permit is required.

The second item may create a problem after the January 1, 1969, regulations for the control of air pollution go into effect. Plant mix bituminous surfacing hot plants will generally be equipped with a "wet scrubber". The discharge from the scrubber will have to be treated so that the suspended solids will not be returned to a surface drainage.

Before being issued a permit, a contractor must submit information to the State Board of Health explaining the treatment process proposed for use.

After a permit is issued, the State Board of Health will determine whether or not the conditions of the permit are being complied with.

Although contractors are to be familiar with the various Federal, State and local laws, you should discuss, at preconstruction conferences, the need for permits for the discharge of waste water to surface drainages.

Personnel of the State Board of Health will be glad to help if questions relating to this matter arise. For copies of permit regulations, permit applications, or questions relating to discharge of wastes, contractors may contact the:

Division of Environmental Sanitation
State Department of Health
Helena, Montana 59601

Air Pollution Control Construction Permits

A Permit is required before burning slash, stumps or debris from clearing and grubbing land for highway construction.

A Permit is required before operating any rock crusher, gravel cleaning or sizing plant, asphalt hot-mix plants or concrete batching plant. Permits are not transferable from one location to another or from one machine to another or from one individual to another.

Permits may be obtained from the:

Director of Air Pollution Control and Industrial Hygiene
Montana State Department of Health
Helena, Montana 59601

14.06 Maintenance of Irrigation Water

The engineer should contact the various landowners and farmers along the course of construction who will be using irrigation water. He should determine what time of the year they will want their water introduced to the fields. The contractor's representative should then attempt to arrange the construction activities so that irrigation water may be introduced when it is needed. The contractor is not permitted to shut off irrigation water in any irrigation ditch without first consulting the water master or the owner of the ditch and securing written approval for the period during which water may be shut off in each and every irrigation ditch. Copies of this written approval should be secured by the Resident Engineer and introduced into his files.

14.07 The Engineer And The Law

The Standard Specifications provide that there shall be no personal liability for the Commission, engineers or their authorized representatives, either personally or as officials of the State. It is understood that in all such matters they act solely as the agents and representatives of the State. However, occasionally it may be necessary for an engineer to appear as an expert witness in various matters concerning the construction contract or in land procurement matters. When such cases occur the following group of suggestions have been set forth to guide the engineers activities and conduct in his relations with the various courts of Montana. An engineer who is called upon to be an expert witness may well find that his reputation and professional future may depend in a large part upon how well he conducts himself on the witness stand.

The engineer may be asked for his testimony and statements of opinion at Highway Commission hearings, legislative hearings, conferences pertaining to contract disputes, hearings to establish valuations of property, before public or private meetings to consider matters relating to the construction contracts, and many other proceedings which are not held in courts but which are nevertheless of great importance. The ability of the individual to express his ideas coherently and to conduct himself well while serving in the capacity of an expert witness and while giving factual evidence or opinions under difficult circumstances may be a great asset to him

An engineer should never attempt to act as an expert witness regarding a matter about which he is not well informed. If he does so, the opposing lawyers and their engineering advisors will be likely to detect his shortcomings and the result may be the utter discredit of his testimony. An expert witness on the stand is fair game for opposing counsel and is in no position to try any bluffing. Erroneous statements open the flood gates; hence, a witness should avoid making broad ascertions unless he is very sure of his ground. When an expert witness is asked for fact rather than an opinion and he cannot answer with assurance,it is best for him to say, "I do not know". One individual is never expected to have answers to everything and occasional admission of ignorance is really no disgrace.

The engineer and the attorney have diverse fields of knowledge and must rely upon each other to considerable extent. When an engineer is assisting an attorney in the study or preparation of the case, the former should be absolutely honest and straightforward in giving his opinions and advice. Even though the engineer's opinion on matters in his own field of activity may not coincide with what the lawyer wishes to hear, the engineer should nevertheless express his ideas as completely and convincingly as he can. If any serious flaws are found in the case it is better to detect them in advance even if it means dropping the suit, than to have them brought out by the opposition at a particularly embarrasing stage of the trial.

An engineering witness must be qualified in order to become or to be accepted by the court as an expert witness. He must give his name and address and will be sworn in by repeating the oath "to tell the whole truth and nothing but the truth, etc". Then he will be asked for information about his background and qualifications by his attorney, in a process of direct examination. The credability of the testimony he is about to give can be established. Examples of various questions that may be asked are as follows:

What is your occupation?
Where and by whom are you employed?
What is the title of your position?
What college did you attend?
What degree or degrees have you received?
Are you a licenses professional engineer?
In what states do you hold a license?
To what professional society do you belong?
Please state briefly an outline of your professional experience.
What are some of your other activities in your profession?
Have you written any articles for engineering periodicals?
If so, to what subjects do they apply in general?
Have you ever worked upon the construction of highways?
Has that work been in the office or in the field?
Please explain in detail the character of this work.

After the qualifications of the expert witness have been brought out by direct questioning similar to the above, the opposing attorney may challenge the standing of the expert witness on the following basis:

1. He is too young to have had satisfactory experience.
2. He is not sufficiently trained in the particular field concerned.
3. He is out of touch with recent developments in this field.
4. His training is too broad or perhaps too specialized.
5. He is too closely connected with the case to have an unbiased opinion.

The expert witness in a court action should conduct himself with dignity and confidence, creating the impression that he truly knows his business, that he is earnestly trying to reveal the facts as he sees them, that he is honest and that his testimony is accurate.

He must be absolutely fair and able to convince the court of his fairness. An engineer who cannot whole-heartedly endorse and support the case should not allow himself to become an expert witness in the impending court action. The expert witness should be courteous at all times. He should maintain his self-control and confidence at all times. Even though he is under nervous tension or under attack by the opposing attorney he should not become angry or allow himself to be intimidated. An engineer witness probably knows far more about his subject than does the opposing attorney and if he is sure of his ground should not fear the opposing counsel.

A court witness should be dressed in conservative neatness and have the appearance of the gentleman that he intends to be.

A witness should not volunteer any information that was not asked. His answers should be short and clear. He should avoid the use of excessive technical language when it is possible to explain the details in more simple words. Words and examples should be chosen so the layman can understand. He should look directly at his interrogator. If he can not answer a question with a "yes" or a "no", he should state that he cannot make an unqualified answer. He can ask for permission to qualify or explain his answer. When a witness is not absolutely positive about replying he should answer "to the best of my knowledge". An expert witness who allows the opposing counsel to demoralize him may cause him to make unwise, untrue or contradictory statements. A witness should be mentally prepared and able to think clearly and speak effectively under these difficult circumstances. He should never blindly accept unproven "facts" as true and never indicate his agreement with a counsel's statements unless he believes them to be true and correct. Leading questions are to be avoided like the plague. These type of questions literally put words into the witness's mouth and are worded to suggest their own answers. For example the proger question"When you inspected the construction site, what did you see?" could be reworded as follows to evoke an untrue response from the witness: "When you inspected the construction site, did you see the damaged roadbed caused by improper compaction?" The damage may have been from some other cause.

False evidence deliberately given amounts to perjury but if a witness does inadvertently say something that is misleading or incorrect he should correct it at the earliest possible moment. This principal applies to any errors found in the maps, plans or direction of work that have been introduced as evidence.

14.08 Insurance Requirements.

(a) General

Adequate insurance coverage must be obtained by the contractor before he can begin any construction activities. The Highway Commission Secretary co-ordinates the insurance requirements. When insurance is satisfactory, the Helena Construction office is notified. This office can then send out the "Notice to Proceed". Similarly, if a contractors insurance coverage lapses, the construction office is promptly notified. A contractor, whose insurance has lapsed, must not be permitted to work until after notice has been received in the field that his insurance coverage is re-newed or otherwise active.

(b) Insurance or fencing contracts

On many projects involving fencing and grading contracts, it should be possible to complete all or most of the fencing work prior to completion of the grading. Contractors involved should be encouraged to cooperate and to coordinate their activities in order to accomplish this.

There have been cases where very little fencing work was done until grading was nearly complete. This creates a hardship for the fencing contractor who normally has only 30 days after notification in which to complete his work.

If the fencing contractor is required to have railroad protective insurance prior to starting work and then is delayed, it is probable that he will have to renew the insurance. This is a costly item on a relatively small contract. The contractor may either delay acquisition of railroad protective insurance until shortly before he will be able to perform his work involving entry on railroad right-of-way or he may complete that portion of work prior to expiration of his insurance.

These matters should be discussed at the Preconstruction Conference and if procurement of insurance may be delayed because work will not be started for some time, notice shall be sent to the Construction Engineer immediately. He shall arrange with the Commission Secretary to have the insurance delayed until needed.

14.09 Preservation of Fish & Wildlife Habitat

There is a growing trend toward considering the total environment in our highway building program. Instead of selecting a route, designing and constructing a highway according to engineering principles only, many other factors must be taken into account.

One area that requires consideration is that of preservation of fish and wildlife habitat. This is desirable not only as good fish and wildlife management but also to retain our scenic heritage.

The following three examples point out ways in which we can exercise some control in this area.

On projects near or crossing streams, care should be taken to minimize disturbing existing streambed conditions or vegetation. Operations which contribute to the addition of silt or other pollutants to streams should be avoided if possible.

While contractors often negotiate with landowners for sites for bases of operation, we should discourage them from "setting up shop" near a stream and building dikes of stream gravel to protect these areas.

Contractors may acquire material sources located so that removal of material will create ugly scars, contribute to stream pollution or in some other manner violate good conservation practices. Landowners may claim that we have no right to interfere in his dealings with a contractor but as long as the materials involved are used in the construction of our highways, we may disapprove any source.

II-15 Prosecution and Progess

15.00 References

Standard Specifications, Section 8

Construction Manual, Section II-14

15.01 Assignment or Subletting of the Contract

The contractor is restricted from assigning more than 50% of his potential earnings or transferring, conveying, or otherwise disposing of his right, title or interest in the contract to any other person, firm, or corporation, without written consent of his surety and of the Highway Commission. The prime contractor is required to perform at least 50% of the work by his own forces under his immediate superintendents. Work items classified in the specifications as specialty items may be sublet and will not fall under the above requirement.

Any subcontractor the prime contractor chooses to use for various items of the work must have been approved by the Highway Commission at least 14 days in advance of his anticipated starting date. Work under a subcontract is not to be started until the subcontractor and his contract has been approved by the engineer. Request for permission to sublet must be in writing, and it is advisable for the Resident Engineer to obtain copies of this written permission and of the subcontract or notice of approval of subcontracts. It is the prime contractor's duty to inform the subcontractor of all the provisions in the contract including minimum wage rates and labor. The subcontractor shall give written assurance to the prime contractor and the engineer that the minimum wage for labor as stated in the proposal shall apply to labor performed on all work sublet or subcontracted. This written assurance is usually complied with on the subcontract form.

The State Highway Commission considers all approved working subcontractors as agents of the prime contractor. Therefore, all information, directives and letters pertaining to the work, are to be directed through the prime contractor to the subcontractor. If a subcontractor does not perform satisfactory work, his subcontract may be terminated by the engineer. Written consent to sublet or transfer the contract shall not release the prime contractor of his liability under the contract involved.

15.02 Start of Work

The contractor will have time charged beginning with the date in the formal notice to proceed with work. Work may begin after contract award and after insurance requirements are met. The practice of allowing a contractor to gain free time on his operating schedule by beginning work before the contract has been awarded shall never be allowed. This practice is contrary to specifications and common sense, because it may allow a Resident Engineer to write contract change orders on work that has never been approved for contract. It would cause a contractor to want payment for work that was accomplished but never placed under contract terms. The engineer would be in a position of attempting to approve work with no specifications to back up his judgment. Tests, records, documentation would be meaningless because a contractor had never agreed to them nor had the State. It should be noted that everything written here applies to the prime contractor and all of his qualified approved subcontractors.

15.03 Preconstruction Conference

A preconstruction conference will be held prior to the actual start of construction. This conference will be between the contractor, the engineer and other parties interested in the proposed construction. The contractor shall determine a satisfactory date for this conference and advise the engineer at least ten days in advance in order that other parties concerned can be advised.

The preconstruction conference can be held in the twenty day grace period between award of contract and the "Notice to Proceed". The contractor should plan to attend, accompanied by such persons as he deems advisable, but it is imperative that the person designated by the contractor, to be in direct charge of construction of the project, be present.

Interested parties are Labor Compliance Section, Equal Employment Opportunity Section (Federally Aided Contracts Only), Highway Safety Director, Bridge Department, Traffic Department, State Industrial Accident Board, Railroad Companies, Utility Companies, Subcontractors, Contractors on adjacent or included units of contract work, Federal Highway Administration and other agencies with similar interests in the intended construction.

Notification to Labor Compliance, Equal Employment Opportunity, Highway Safety Director, Bridge Department, Traffic Department, State Industrial Accident Board, will be handled through the Construction Division. A letter or telephone call should suffice as notification to other parties interested in attending.

Small contracts should not have the preconstruction conference conducted over the telephone, rather a regular group preconstruction conference shall be held for all contracts whether large or small.

Arrangements for the preconstruction conference will be at the mutual convenience of all intended participants. We strongly recommend that one group conference be held for and be attended by the contractors of different units on one project.

Topics that are important to the Construction Office and to your own office are: The expected starting date of construction; the contractor's intentions for subcontracting, (what items and to whom); and the expected delivery date of major materials, such as pipe, steel, signs, etc., and contractors expected schedules.

A written report of the preconstruction conference must be made immediately upon conclusion of the meeting. The original and one copy shall be submitted to the Construction office no later than two (2) days after the meeting. The Construction Office will make distribution to the Federal Highway Administration when warranted. Copies should be made and distributed to the Division Engineer, Resident Engineer, Labor Compliance Section, Equal Employment Opportunity Section, Safety Coordinator, Industrial Accident Board, Materials Division and other sections of the Highway Commission when involved. Contractors and Subcontractors should also receive a copy of the report. When only Bridge contracts are involved the Construction Division should receive a copy. Other interested parties should receive a copy at their request.

Conduct of the Meeting

The following checklist may be used as a guide in conducting the preconstruction conference. Particular emphasis should be placed on documentation, field measurements and joint cooperation between the contractor and the engineering crews.

1. In advance of the meeting check to see if all interested parties have been invited to the meeting.

    a. Contractor
    b. Subcontractors
    c. Resident Engineers
    d. Soils Engineer
    e. Safety Coordinators
    f. Labor Compliance Section
    g. Equal Employment Opportunity Section
    h. Construction Division
    i. Representatives of the utility companies
    j. Representatives of counties or municipalities
    k. Representatives of railroad companies
    l. Right-of-way Division Personnel

2. Introduce those persons present to each other.

3. Recording of minutes. Assign an individual to act as recording-secretary. This individual should take the attendance records, names, company represented, address and telephone number.

4. A description of the work to be done should be given.

5. Supervisors both for the contractor and the State should be designated.

    a. Highway Commission engineers, Resident Engineer and associated resident engineers or instrumentmen.
    b. Contractor's project manager, superintendent, or responsible foreman, whoever has been designated to act as the agent for the contractor.

6. Subcontracting and lease rental agreements should be gone over.

7. Right-Of-Way

    a. Status of unsecured parcels if such exist.
    b. Special conditions that may be required under various right-of-way parcels or agreements.
    c. Buildings that may have to be removed.

8. Utilities and railroads
   a. Schedule for removal and relocation of facilities.
   b. Designation of temporary crossing
   c. Designation of supervisory personnel for the railroad or utility company.
   d. The contractor should be told to give the railroad company plenty of advance notice before working across or near their tracks.

9. Municipalities or counties affected
   a. Their utilities.
   b. Proper haul routes, weight restrictions, bonds, other various requirements.
   c. Hauling hours or other construction restrictions due to traffic anti-noise ordinance, air and water pollution requirements.
   d. Designation of adequate safety measures.
   e. Approval by State Health Department for construction or relocation of sanitary sewers.

10. Materials control
    a. Intention of State Highway Commission to enforce all specifications involving materials.
    b. Contractor is responsible for untested material.
    c. Brief review of special provisions pertaining to or providing particular emphasis on various materials.
    d. Soils engineer or materials supervisor should discuss borrow pits, any selective gradings required, requirement that contractor submit list of his proposed source of all materials.

11. Construction traffic control
    a. Maintaining traffic and traffic safety through construction zones.
    b. Project identification signs.
    c. Control of dust.
    d. Cooperation with local traffic authorities.
    e. Proposed locations of extensive detours and intended method of traffic control and construction signing.

12. Construction safety program
    a. Discussion by the safety engineer or safety coordinators.

13. Change orders, work orders and similar recommendations
    a. No work is authorized to proceed until acceptance and approval of change order, work order, or supplemental agreement.
    b. Designate authorized representative of prime contractor to sign authorizations for change orders, work orders, supplemental agreements.
    c. Requirements for notification of claims prior to undertaking work if extra reimbursement is requested by contractor.

14. Labor Compliance

    a. Contractor's payrolls and reports. State's intention of making periodic or frequent spot checks. Posting of minimum wage determinations.
    b. Federal Highway Administration regulations, various inspections.
    c. The quality of pay documentation and payment practices.
    d. Intention to be fair in all dealings with the contractor, how disputes and controversies are to be handled. Resident to Division to District to Construction to State Highway Enigneer then Commission.

15. Equal Employment Opportunity

    a. Requirements for Federal Aid Projects.
    b. Reporting procedures.
    c. Responsibilities of EEO Officers, Division and Resident Engineer
    d. On the job training when applicable.

16. Miscellaneous discussions

    a. Special agreements
    b. Fish and Game requirements for preservation of trout streams and lakes in recreation areas or similar locations abutting or bordering the highway construction.
    c. Insurance requirements should be discussed. See Section 14.08.

15.04 Work Suspension and Resumption

(A) General

The Resident Engineer will decide whether to suspend or resume work. Suspension and resumption of any of the work is not to be done without a written order. Should the contractor elect to suspend work without such written order, contract time will continue as if the contractor were working. The contractor shall be responsible for any damages to the work from any cause whatsoever.

Should it become necessary to suspend work for an indefinite period of time, the contractor is required to protect the construction that has been partially completed or completed by providing adequate drainage for the roadway, opening ditches, making shoulder drains, or undertaking any other precautions the engineer may direct. He should store all materials in an acceptable manner so that they will not impede the traveling public nor become damaged or stolen during the period of suspension.

Suspension and resumption of work will be carried on Forms C-3 and C-4. Examples of these forms are found on Figures II-4 and 5.

When work is suspended for reasons entirely within the control of the contractor, those working days are charged against the working day allotment. Materials which do not comply with specifications, improper men or equipment, and failure to perform the directions of the work are some of the reasons within the contractor's control that would cause a work suspension. Notification to suspend work in such cases should always be in writing. When the reason for suspension no longer exists, if it can be expected that favorable conditions will prevail for resumption in writing. Whether work suspension is due to reasons within the control of the contractor or are caused by difficulties outside of his control, construction Form C-3 and C-4 should be used to convey the messages intended.

It may be impractical to begin work on the effective date of the proceed order. This could be true due to the lateness of season, inclement weather, utilities in the way, acts of God, field engineering not far enough advanced to permit an orderly prosecution of the work or other conditions. A suspend order should be initiated by the engineer in charge.

(B) Seasonal Suspension

On projects let to contract after October 1, 1970 time will not be charged from November 16 through April 15. This will eliminate the need for seasonal suspend orders (eg. Winter Shutdown). During this period the contractor is expected and should be encouraged to accomplish as much work as possible. If the contract contains an item for providing and maintaining detours the contractor is still obligated to perform this work even though no time is being charged.

Immediately after November 16 the contractor is to be informed by means of Form C-3(A) of the time charged to his contract through November 15 and the time remaining. An example of this form is found on Figure II-7.

Seasonal suspension still applies to projects let to contract prior to October 1, 1970 and will have to be administered accordingly.

It is important to note, that there is a distinct difference between an ordinary time suspension and a seasonal suspension (eg. Winter Shutdown). These orders individually denote who is responsible for maintenance and whether or not the contractor is permitted to accomplish partial work during an authorized suspension.

When a project is placed under a seasonal suspend order (eg. Winter Shutdown), the contractor is freed of maintenance responsibility for the project until an "Order to Contractor to Resume Work" (Form C-4), is issued. The Contractor is not allowed to work, under a seasonal suspend order, except for stockpiling aggregates (for which no time is to be charged). A seasonal suspension should not be issued if the contract contains an item for providing and maintaining detours.

If a contractor elects to perform partial work during a period of suspension, an ordinary time suspension shall be issued rather than a seasonal suspension. The responsibility and cost for maintenance is then the contractor's with the exception of snow removal. Time is assessed in proportion to the value of the work performed, by issuing an "Assessment for Minor Work" (Form C-5).

Sometimes projects are let with the condition that the contractor must complete the work through a certain phase before a seasonal suspend order will be issued. The intent is to encourage the contractor to pursue his work so that the traveling public has a generally acceptable roadway during the period of suspension.

His failure to complete work through this phase will necessitate his assuming responsibility for maintenance.

Please indicate on the "Order to Contractor to Suspend Work" if a seasonal suspend order is to be issued. An example of this is shown on Figure II-5A.

(C) Issuance of Suspend Orders

Care must be exercised in the issuance of suspend orders. The following items show ways of handling some of the problems encountered.

1) If a suspend order is issued due to the late delivery or non-availability of critical materials the Standard Specifications require the contractor to provide letters from independent suppliers substantiating this. The contractor must have all non-related work accomplished.

2) Suspend orders may be issued for delays caused by lengthy curing periods, such as those required when sealing road mix or plant mix bituminous pavements. Again it is assumed that other unrelated work has been completed.

3) Suspend orders are not to be issued upon completion of all but minor items of work. Time is to be charged until final acceptance of the project. (This is required by Specifications). If contract time has expired, every effort should be made to make the final inspection when work is completed. In no case should the delay of a final inspection cause a contractor to incur liquidated damages.

4) Explain clearly the reason for the suspend order. Do not use the reason "Inclement Weather", without explaining what made it inclement and how this affected the work. For example, if inclement weather is meant for "high winds which made it impractical to paint or apply vegetative mulch", say this on the suspend order.

15.05 Limitation of Operations

The Standard Specifications for Road and Bridge Construction are clear in their intention that the Resident Engineer is responsible for directing work so that adequate progress is being made and that convenience of the public is provided for at all times. The engineer may direct performance of such work as is necessary to expedite completion. The engineer must be reasonable in his interpretation of the specifications but he also must require adequate progress of the work.

15.06 Contract Time

The authority and responsibility for the assessment of contract time will lie entirely at the field level governed only by regulations contained in the contract provisions and policy that may be established from time to time.

The time allowed for completion of the contract is determined by either the calendar day or calendar date method. On most contracts the calendar day method is used, however, in some instances it may be imperative that a project be completed by a certain date, in which case a calendar date is specified. Under the calendar date method, suspend or resume orders are not issued. Extension of time under the calendar date method does not occur unless conditions or events beyond the control of contractor prevent completion of the project by the date specified.

Each and every calendar day will be judged on its own merits, whether it is or is not assessible, and its status must be resolved not later than the following day.

Do not charge time for the period between the dates of completion and final inspection.

Time will be assessed if the weather is such that the contractor could economically and feasibly progress on the major items of work with more than 50% efficiency. This rule applies whether the contractor actually works or not and whether he is physically on the project or not.

All information pertinent to the contract time should be placed in the appropriate pages of the project diary.

Any delay in awarding a contract of more than one (1) day after the opening of bids will extend the completion date a corresponding number of calendar days, on calendar date contracts.

The Resident Engineer should carefully look over the special provisions, proposal and other terms of the contract for matters peculiar to that one contract. Clauses other than the usual contract time clause may appear, such as, "no work is to be started until all materials are on the job available for incorporation into the work; or the contractor shall not begin work intil a certain date." Such clauses if not executed properly will cause much difficulty in assessing liquidated damages or completing a project on time.

The Certificate of Completion has spaces to show approved time extensions and total time allowed. Hopefully, by the time the project is complete, everyone is in agreement as to the status of time remaining or the time by which the contract has overrun.

If a contractor finds it impossible to complete his work within the contract time due to reasons beyond his control, he may request, in writing, an extension of time prior to the expiration of contract time. (This is in accordance with the Standard Specifications). If this is done and the request is reasonable, a change order should be initiated for the change in contract time. A copy of the contractor's request should accompany the change order.

(B) Evaluating an Overrun of Contract Time

If an overrun of contract time occurs, the following items should be considered when evaluating the situation.

1) Did the contractor delay start of work for an unreasonable period of time following the award of his contract? Some time is necessary for contractors to acquire the necessary insurance, move in equipment and personnel and make other necessary arrangements prior to starting work. Twenty (20) days are allowed on calendar day projects between contract award and issuance of the proceed order. Time charge begins on the day of award of calendar date projects.

2) Did the contractor have adequate equipment and personnel to efficiently perform the work?

3) Were there delays to the contractor's progress due to his negligence or other reasons within his control? Did he request, in writing, time extensions for delays not within his control?

4) Was the contractor given credit for additional time as shown on change orders, extra work orders and supplemental agreements? Was he allowed time for additional work not great enough to require change orders? Was the work and material shown on change orders or E.W.O.'s actually incorporated into the project? If not, the time shown for this work and material should be dismissed.

5) Was the completion date extended an amount equal to the delay of award (applies only to calendar date projects - see the Standard Specifications for determination and extension of contract time).

6) Was the project open to traffic and essentially complete when the contract time expired? If so, this fact should be given favorable considerations. (The Standard Specifications under Failure to Complete on Time states, "The Commission may waive such portions of the liquidated damages as may occur after the work is in condition for safe and convenient use by the traveling public").

The above factors are not necessarily the only ones to consider, but are meant to serve as guides.

(C) Assessment for Minor Work

A contractor may accomplish partial work during a period of authorized work suspension. If the value of the work accomplished amounts to earnings in excess of $500.00, contract time will be charged for that work.

Time will not be assessed for minor work accomplished on projects let to contract after October 1, 1970, during the period from November 16 to April 15.

The use of Form C-5, "Assessment for Minor Work," eliminates the necessity of issuing a Resume Work Order and a Suspend Work Order to assess contract time for each monthly earning in excess of $500.00, accomplished during a period of authorized work suspension. Use Form C-5 in conjunction with the C-3 and C-4 Forms.

In filling out Form C-5, the time assessed will be the ratio of the actual value of the partial work completed during the suspension, divided by the total dollar amount of the contract as awarded, then multiplied by the total number of days of contract time as awarded. However, in no case would it be correct to charge contract time (because of partial work performance), in excess of the number of days authorized suspension occurring within that particular period. Production and stockpiling of surfacing aggregates will not be considered as partial work during an authorized period of work suspension.

An example of documentation for a time charge due to partial work accomplished within a period of authorized work suspension may be seen in Figure II-4.

15.07 Liquidated Damages

Each contract has a clause providing for deduction from any money due the contractor should he fail to complete the contract within the allotted time. It is therefore, imperative to permanently record through the use of suspend and resume orders and in the project diary, any suspensions, resumptions of work, extensions of time or delays in the work whether within the control of the contractor or not.

Assessment of liquidated damages by the field, requires review and approval by the State Highway Commission and the Federal Highway Administration. Written records that document reasons for delays and reasons for time extensions, are to be submitted to the Construction Engineer at the completion of a contract along with the recommendations of the Division and Resident Engineers.

The letter written to the Construction Division describing time overruns and recommendations for assessment or waiver of liquidated damages is to include time allowed for approved overruns under the $5,000.00 limit.

15.08 Certificate of Completion

(A) General

The "Certificate of Completion of Construction Contract" form is designed to include approved time extensions allowed for extra and/or additional work. (See Figure II-5). The Suspend and Resume work orders will show the total of all approved time extensions through the specified date of the respective order, and the Certificate of Completion will show the final total of all approved time extensions.

The time extensions allowed for work performed in accordance with a Supplemental Agreement should be part of the agreement. The extra time should be computed by the "Money Formula." If this is not reasonable, it should be adjusted and explained.

When the revised contract time or date as shown on the Certificate of Completion exceeds the number of calendar days used or extends beyond the work completion date, it will not be necessary to submit a recommendation for waiver of Liquidated Damages.

In the section titled "Gross Overrun in Contract Time or Net Time Credit", please strike out the item not applicable when submitting a revised Certificate of Completion.

The Certificate of Completion should be submitted immediately to serve as notice of actual contract completion. If a delay is necessitated in submitting the Certificate of Completion, the Division Office shall notify the Construction Office, by teletype, of project completion and reason for delay in submitting said form.

The procedure of showing approved time extensions on the Suspend, Resume and Completion Forms should keep the contractor well informed and keep our own records up-to-date on chargeable contract time. It will also eliminate the need for writing recommendations for waiver of liquidated damages when contract time plus approved time extension exceed the completion time.

(B) Secondary Projects

Agreement of acceptance of Secondary Projects by the County Commissioners is required. After the District Engineer conducts the County Commissioners on an inspection of the project, their signatures on an acceptance report should be obtained. Construction Inspection Report Form No. 1 can be used for this purpose.

15.09 Default and Termination of the Contract

The contractor may be held in default or have his contract terminated if he violates any of the requirements listed in the Standard Specifications.

Any action taken by the Commission must be based on the written recommendations of the Resident Engineer and his superiors. The report should contain the necessary proof of violation, various memorandums issued to the contractor pertaining to the situation, list of work percentages uncompleted, review of the problems encountered and corrective action taken and any other information that will aid in a factual interpretation by the Commission.

15.10 State Law Restricting Bidding

A state law, applicable to contracts awarded since July 1, 1969, forbids a contractor to take another public contract if time has expired on a current project that he is working for the State, County or City. The time expired is to include all authorized time extensions.

A contractor who is out of time on a previously awarded public contract will not be awarded another project until the current project is completed, but he will be permitted to bid.

A weekly letter provides an indication of those contractors that may be in trouble, but this information is usually not complete enough so that a formal decision can be based on it.

The Construction and Bridge Divisions have records of approved time extensions and suspend orders, but there are often pending change orders, extra work orders, overruns for which no change orders have been submitted, and possible other factors affecting time charge that only the Division has knowledge of.

The Construction or Bridge Office needs an explanation for all projects in each Division for which contract time has expired or will expire before the next letting. The explanation should include the project number and designation, the date on which original contract time expired, total days of approved time extensions, pending time extensions (with explanation), additional time for estimated overruns of quantities not included on change orders, other factors that you believe warrant a time extension, and your estimate as to when contract time, including approved and non-approved extensions will expire.

In line with this, the District Engineers and Division Engineers will then check all construction projects under their respective jurisdictions on the Friday preceding a letting to ascertain if any contractor is overtime. Then the District Engineers will notify both the Bridge Engineer and the Construction Engineer.

The Bridge Engineer and the Construction Engineer will then check with the Office Engineer on the letting date to determine who received the low bid and the second low bid on all projects. If a contractor is overtime on any project and has submitted the low bid or the second low bid, they will notify the State Highway Engineer in writing at once giving all the particulars for overtime.

The State Highway Engineer will then present all facts to the Montana State Highway Commission. They will make the final decision before the contract is awarded.

The Office Engineer will, as in the past, give live proposals to all contractors who are qualified to bid the project, disregarding the overtime factor.

An example of the desired information is shown below for your guidance. It may be transmitted by memorandum or teletype.

EXAMPLE

REF: I 90-10(1) 1 U-1
Brazzavile-E & W

CONTRACT TIME: 300 Calendar Days
CONTRACT LET & AWARDED: February 27, 1969
EFFECTIVE DATE PROCEED ORDER: March 19, 1969
WORK STARTED: March 26, 1968
300 Calendar Days allowed for completion expired at close of work June 9, 1969.

16 additional days have been allowed to date for approved additional work. These additional days expired at the close of work July 3, 1969.

Due to heavy rain calendar days were not assessed July 4th to July 8th, inclusive.

Additional work not yet convered by approved change orders include 100.000 cubic yards unclassified borrow excavation and approximately (finishing and remeasure not complete) 150.000 cubic yards unclassified excavation. Based on the money formula this work will allow an additional 15 calendar days and extend the contract time through the close of work on July 25, 1969, this date subject to change pending weather conditions.

The contractor's progress has been good during the past week and it now appears probable that this project will be complete within the allowed contract time.

Form C-2
Revised 8/20/70

STATE OF MONTANA HIGHWAY COMMISSION

ORDER TO CONTRACTOR TO PROCEED WITH WORK

HELENA, MONTANA

DATE: October 2, 1967

TO: F & S Contracting Company
1300 Chicago Street
Butte, Montana 59701

GENTLEMEN:

In accordance with terms of the contract proposal submitted by you and accepted September 26, 1967 by the State of Montana Highway Commission for construction of Highway Project F 73(5) U-1 (Alt. B), Riceville-Armington Road in Cascade County or Counties, you are hereby authorized to proceed with work on this project, provided that the specified liability insurance has been filed with the Commission.

Federal Highway Administration concurred in award of this project on 9/28/67.

In any case, assessment against the 280 Calendar Days stipulated for completion of this project will be started on October 18, 1967 unless a suspend work order is issued prior to this date.

Please sign both copies in the space provided, retain the original and return the copy in the self-addressed envelope.

Receipt of this order is hereby acknowledged:

DATE: October 5, 1967

F & S Contracting Company
(Contractor)

BY: Louis Mohr

TITLE: General Superintendent

Respectfully,

STATE HIGHWAY COMMISSION

Lewis M. Chittim, P.E.
State Highway Engineer

By
Construction Division

DISTRIBUTION: Original - Contractor
Copies - Construction Engineer
Commission Secretary
Accounting
Mail & File
Bridge
District Engineer -
Division Engineer -
Resident Engineer
Bureau of Public Roads/2
Lab
Labor Compliance/2

Figure II-1

Rev. 4-1-71

Form C-5
(4/1/69)

STATE HIGHWAY COMMISSION OF MONTANA

ASSESSMENT FOR MINOR WORK

Belt, MONTANA

DATE: April 21, 1969

TO: F & S Contracting Company
1300 Chicago Street
Butte, Montana 59701

PROJECT: F 73(5) U-1
Riceville-Armington

GENTLEMEN:

By reason of minor work accomplished in excess of five hundred dollars ($500.00) from November 30, 19 68, date of the last Suspend Order or Assessment for Minor Work Order through the date of this order, computed on the pro rata basis of value of work performed during this period, you are hereby assessed 4 calendar days in accordance with Article 08.06 of the Specifications.

Under the terms of your contract for the above subject project, 280 calendar days are allowed to complete this project, and 36 days have been allowed for approved extra and/or additional work. At the close of work on the date specified in the last Suspend Order or Assessment for Minor Work Order 200 of the 316 days had been used and there remain 116 days in which to complete the contract.

Please sign all five copies in the space provided and return them to this office in the self-addressed envelope. One approved copy will be returned for your files.

Receipt of this order is hereby acknowledged:

DATE: April 21, 1969

F & S Contracting Company
CONTRACTOR

BY:

TITLE: Superintendent

Respectfully,

STATE HIGHWAY COMMISSION OF MONTANA

Lewis M. Chittim, P.E.
State Highway Engineer

BY:

TITLE: Resident Engineer I

APPROVED: January 24, 1969
(Date)

BY:
DIVISION CONSTRUCTION ENGINEER

DISTRIBUTION:
Original - Contractor
Copies - Construction Engineer
Div. Constr. Engineer
Resident Engineer
District Engineer
Bridge Engineer

Rev. 4-1-71

Figure II-2

Form C-4
Revised 4/1/69

STATE HIGHWAY COMMISSION OF MONTANA

ORDER TO CONTRACTOR TO RESUME WORK

Belt, MONTANA

DATE: April 21, 1969

PROJECT: F 73(5) U-1

TO: F & S Contracting Company
1300 Chicago Street
Butte, Montana 59701

GENTLEMEN:

Under date of November 30, 1968, you were directed to suspend work on your contract, for reasons of the conditions described in the Suspend Order. Conditions now having assumed a status suitable to the favorable prosecution of the work, you are hereby directed to resume major operations on this project on April 21, 1969.

Under the terms of your contract for the above subject project, 280 calendar days are allowed to complete this project, and 36 days have been allowed for approved extra and/or additional work. At the close of work on the date specified in the last suspend order or assessment for minor work order, 200 of the 316 days had been used and assessment against the remaining 116 calendar days will be resumed on the date herein above specified.

Please sign all five copies in the space provided and return them to this office in the self-addressed envelope. One approved copy will be returned for your file.

Receipt of this order is hereby acknowledged:

DATE: April 21, 1969

F & S Contracting Company
CONTRACTOR

BY:

TITLE: Superintendent

Respectfully,

STATE HIGHWAY COMMISSION OF MONTANA

Lewis M. Chittim, P.E.
State Highway Engineer

BY:

TITLE: Resident Engineer I

APPROVED:
(Date)

BY:
DIVISION CONSTRUCTION ENGINEER

DISTRIBUTION:
Original - Contractor
Copies - Construction Engineer
Div. Constr. Engineer
Resident Engineer
District Engineer
Bridge Engineer

Figure II-3

Form C-3
Revised 4/1/69

STATE HIGHWAY COMMISSION OF MONTANA

ORDER TO CONTRACTOR TO SUSPEND WORK

Belt, MONTANA

DATE: April 26, 1969

TO: F & S Contracting Company
1300 Chicago Street
Butte, Montana 59701

PROJECT: F 73(5) U-1
Riceville-Armington

GENTLEMEN:

By reason of Excessive rainfall saturating the work area making it impossible to conduct grading operations.

which renders it impracticable for you to secure specified results on the work required of your contract, you are hereby directed to suspend work (minor operations excepted), at the close of work on April 25, 1969.

You will resume major operations only when instructed to do so in writing by a Resume Work Order issued by the Engineer.

Under the terms of your contract for the above subject project, 280 calendar days are allowed to complete this project and 36 days have been allowed for approved extra and/or additional work. At the close of work on the date herein above specified, 205 of the 316 days have been used and there remain 111 calendar days in which to complete the contract.

Please sign all five copies in the space provided and return them to this office in the self-addressed envelope. One approved copy will be returned for your files.

Receipt of this order is hereby acknowledged:

DATE: April 26, 1969

F & S Contracting Company
CONTRACTOR

BY: __________

TITLE: __________

Respectfully,

STATE HIGHWAY COMMISSION OF MONT

Lewis M. Chittim, P.E.
State Highway Engineer

BY: __________

TITLE: Resident Engineer II

APPROVED: __________
(Date)

BY: __________
DIVISION CONSTRUCTION ENGINEER

DISTRIBUTION:
Original - Contractor
Copies - Construction Engineer
Div. Constr. Engineer
Resident Engineer
District Engineer
Bridge Engineer

Figure II-4

Rev. 4-1-71

Form C-4
Revised 4/1/69

STATE HIGHWAY COMMISSION OF MONTANA

ORDER TO CONTRACTOR TO RESUME WORK

Belt, MONTANA

DATE: May 1, 1969

TO: F & S Contracting Company
1300 Chicago Street
Butte, Montana 59701

PROJECT: F 73(5) U-1
Riceville-Armington

GENTLEMEN:

Under date of April 25, 1969, you were directed to suspend work on your contract, for reasons of the conditions described in the Suspend Order. Conditions now having assumed a status suitable to the favorable prosecution of the work, you are hereby directed to resume major operations on this project on May 1, 1969.

Under the terms of your contract for the above subject project, 280 calendar days are allowed to complete this project, and 36 days have been allowed for approved extra and/or additional work. At the close of work on the date specified in the last suspend order or assessment for minor work order, 205 of the 316 days had been used and assessment against the remaining 111 calendar days will be resumed on the date herein above specified.

Please sign all five copies in the space provided and return them to this office in the self-addressed envelope. One approved copy will be returned for your file.

Receipt of this order is hereby acknowledged:

DATE: May 1, 1969

F & S Contracting Company
CONTRACTOR

BY:

TITLE: Superintendent

Respectfully,

STATE HIGHWAY COMMISSION OF MONTANA

Lewis M. Chittim, P.E.
State Highway Engineer

BY:

TITLE: Resident Engineer I

APPROVED:
(Date)

BY:
DIVISION CONSTRUCTION ENGINEER

DISTRIBUTION:
Original - Contractor
Copies - Construction Engineer
Div. Constr. Engineer
Resident Engineer
District Engineer
Bridge Engineer

Figure II-5

Form C-3
Revised 4/1/69

STATE HIGHWAY COMMISSION OF MONTANA

ORDER TO CONTRACTOR TO SUSPEND WORK

Glendive, MONTANA

DATE: November 20, 1971

TO: Jones Construction Company
1000 Elm Street
Billings, Montana 59101

PROJECT: F 333 (33)

GENTLEMEN:

By reason of Snow (12 inches), low temperature (-10^0) and frozen subgrade This constitutes a seasonal suspend order.

which renders it impracticable for you to secure specified results on the work required of your contract, you are hereby directed to suspend work (minor operations excepted), at the close of work on November 19, 1971.

You will resume major operations only when instructed to do so in writing by a Resume Work Order issued by the Engineer.

Under the terms of your contract for the above subject project, 200 calendar days are allowed to complete this project and 10 days have been allowed for approved extra and/or additional work. At the close of work on the date herein above specified, 200 of the 210 days have been used and there remain 10 calendar days in which to complete the contract.

Please sign all five copies in the space provided and return them to this office in the self-addressed envelope. One approved copy will be returned for your files.

Receipt of this order is hereby acknowledged:

DATE: ____________

____
CONTRACTOR

BY: ____________

TITLE: ____________

Respectfully,

STATE HIGHWAY COMMISSION OF MONTANA

Lewis M. Chittim, P.E.
State Highway Engineer

BY: ____________

TITLE: ____________

APPROVED: ____________
(Date)

BY: ____________
DIVISION CONSTRUCTION ENGINEER

DISTRIBUTION:
Original - Contractor
Copies - Construction Engineer
Div. Constr. Engineer
Resident Engineer
District Engineer
Bridge Engineer

Figure II-5A

Rev. 4-1-71

REV. 4/1/69

MONTANA HIGHWAY COMMISSION

CERTIFICATE OF COMPLETION OF CONSTRUCTION CONTRACT

Great Falls, MONTANA

November 6, 1969 DATE

I HEREBY CERTIFY THAT THE CONTRACT FOR Federal Aid Primary

PROJECT NO. F 73(5) U-1 IN Cascade COUNTY

ON Riceville-Armington ROAD,
(Project Designation)

FOR grading, aggregate surfacing and plant mix bituminous surfacing on 11.121 miles of the Riceville-Armington Road in Cascade County. (Type of Work)

11.121 MILES, THE CONTRACTOR FOR WHICH IS F & S Contracting Company,

WAS FINALLY COMPLETED ON November 4 19 69, IN FULL ACCORDANCE WITH THE PLANS, SPECIFICATIONS AND SPECIAL PROVISIONS THEREFOR. I FURTHER CERTIFY THAT I MADE FINAL INSPECTION OF SAID PROJECT ON November 4, 19 69, AND DULY VERIFIED THE DATE OF COMPLETION ABOVE GIVEN AND THE FACT THAT SAID PROJECT WAS FULLY AND SATISFACTORILY COMPLETED ON SAID DATE. I, THEREFORE, RECOMMEND AS THE DULY AUTHORIZED REPRESENTATIVE OF THE MONTANA HIGHWAY COMMISSION THAT THE CONTRACT FOR THE ABOVE PROJECT BE FINALLY ACCEPTED.

CONTRACT LET	September 26, 1969	CONTRACT TIME or COMPLETION DATE	280 Calendar Days
CONTRACT AWARDED	September 28, 1967	APPROVED TIME EXTENSIONS	49 Calendar Days
PROCEED ORDER DATE IF CALENDAR DAY PROJECT	October 18, 1967	REVISED CONTRACT TIME or DATE	329 Calendar Days
WORK STARTED	October 16, 1967	NUMBER OF CALENDAR DAYS USED	327 Calendar Days
WORK COMPLETED	November 4, 1969	GROSS OVERRUN IN CONTRACT TIME or NET TIME CREDIT	2 calendar days

DIVISION ENGINEER

DISTRICT ENGINEER

ACCEPTED:

MONTANA HIGHWAY COMMISSION

BY:
STATE HIGHWAY ENGINEER

(Date)

I CONCUR IN THE ABOVE RECOMMENDATIONS:

CONSTRUCTION - BRIDGE ENGINEER

(Date)

SUBMIT TO HELENA IN QUADRUPLICATE IMMEDIATELY UPON COMPLETION OF PROJECT.

Figure II-6

C.O.#	Additional Days
2	+4
4	+1
6	+1
7	+2
8	+1
13	+9
14	+1
18	+2
21	+3
22	+4
23	+3
24	+2
25	+2
27	+1
29	+1
30	+3
31	+5
34	+1
E.W.O. #5	+1
	+2*
	+49

* Time allowed for approved overruns under $5,000.00 but not requiring change orders. Time is computed by money formula.

Note to reader of Manual:

The above summary is placed on the back page of the certificate of completion as help in review of time used on a project.

Figure II-6(a)

Form C-3 (A)
(1/7/71)

STATE HIGHWAY COMMISSION OF MONTANA

NON-ASSESSABLE CONTRACT TIME

Billings, Montana

Date: November 20, 1971

TO: Jones Construction Company
1000 Elm Street
Billings, Montana 59101

GENTLEMEN:

Article 08.06 Supplemental Specifications
Under the terms of "Contract Time", Item ______, of the Special Provisions, calendar days between the dates of November 16 and April 15, inclusive, are not charged to the 200 Calendar Days allowed in which to complete the project. Therefore, at the close of work on November 15, 1971, 100 of these days have been used and there remain 100 Calendar Days after April 15, 1972, to complete the contract for Federal Aid Project F 100 (10).

Respectfully,

LEWIS M. CHITTIM, P.E.
State Highway Engineer

BY: ______________________

TITLE: Resident Engineer II

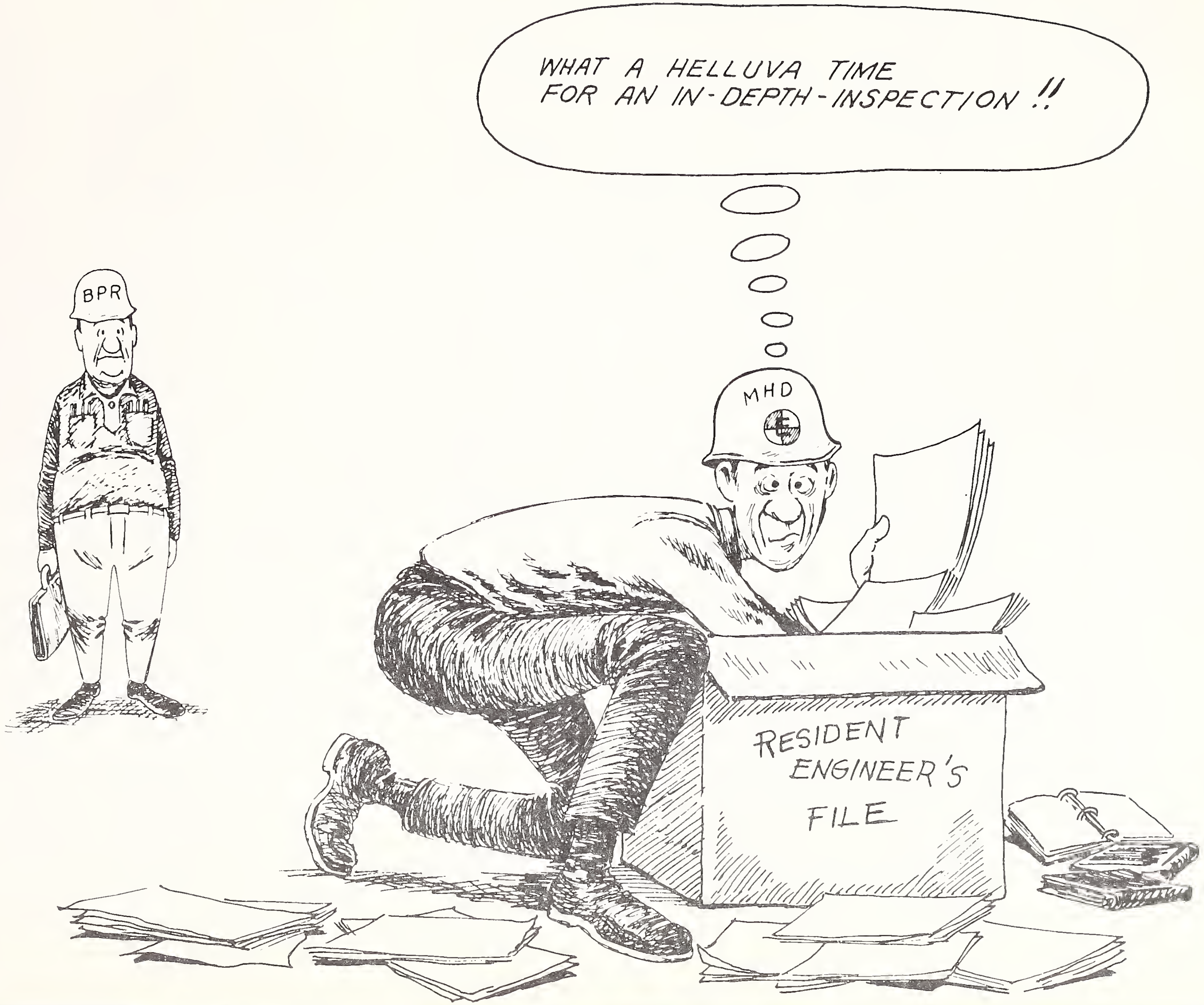
APPROVED: ______________________

BY: ______________________
Division Construction Engineer

HGW/db
DISTRIBUTION:
Original - Contractor
Copies - Construction Engineer
Div. Const. Engineer
Resident Engineer
District Engineer
Bridge Engineer

Figure II-7

Rev. 4-1-71


WHAT A HELLUVA TIME
FOR AN IN-DEPTH-INSPECTION !!
BPR
MHD
RESIDENT
ENGINEER'S
FILE

II-16 Measurement and Payment

16.00 References

Standard Specifications, Section 9; Construction Manual, Section I-05

16.01 General

Throughout the book of specifications there are listed, under the details of construction, the various methods of measurement and payment. The engineer, when reviewing any plans and specifications or in dealing with the contractor's requests, should think in terms of how is it to be paid for, and how is it to be measured.

Contract items are measured for payment on the unit basis. Work is paid for by the units of count, length, area, volume, weight, or lump sum. The unit of measurement for any particular item is given in the specifications under the applicable section. Article 09.01 in the Standard Specifications lists the definitions and the methods of measurement for all the items expected to be in any contract; however, if questions arise in the field as to how to measure or how to pay for any item, the Division Engineer should be contacted for clarification of the method of measurement or payment.

Quantities of contract items are to be measured and calculated to a degree of accuracy consistant with the bid prices of the item unless otherwise directed or specified. The engineer should check the standard specifications or the special provisions for the unit and method of payment and unless otherwise changed he should use the following list of bid price and significant decimal for his payment of quantities.

Bid Price	Significant Decimal
Less than $1.00 per unit	1.0
$1.00 to $10.00 per unit	0.1
$10.00 to $100.00 per unit	0.01
over $100.00 per unit	0.001

The above figures will be used to indicate the decimal places for significant information such as the accumulative days total run of measurements or weighing, the quantities reported on progress, semi-final estimates, and other instances which require the engineer's judgment to determine the significant totals or figures.

Quantities of some items such as fencing and culverts are measured along their length on the slope rather than horizontally. The specifications should therefore be checked for the required method of measurement for each item.

Measurement of volume by vehicle load is not a desirable method of determining quantity since it is not possible to fill the load each time exactly to water level capacity. This system is to be used only when quantities needed are so small that it would be uneconomical to set up a scale.

Any request for conversion from a weight basis to a volume basis by vehicle measurement will not be favorably considered unless it is small and there are other extenuating circumstances such as a long haul to the scales or if the work is being done early in the job and the scales have not been erected or are not available.

Any change in the method of measurement should be backed up by a written request from the contractor to make the change. If any changes in the method of measurements are allowed, there usually is a reduction in the cost to the contractor. This cost reduction should be passed along to the State, either in the form of a letter from the contractor to the engineer or placed on a change order.

16.02 Pay Quantity Documentation

Much has been said in previous portions of the manual about pay quantity documentation. This chapter will concern itself with the same subject. In other portions of the construction manual, especially under construction details, methods will be set out for determining and recording the pay quantity documentation for each item in the contract that is involved.

The Resident Engineer is responsible for assuring that complete and accurate records are maintained. Erasures are not permitted in field books. If an item is recorded in error, draw a line through it without destroying its legibility and record the correct number. Copying of notes must be avoided. If it is essential to copy, the copied part must be so marked and the original submitted as a part of the notes. Each day's notes shall be dated and initialed. When adding new data to notes previously prepared, each new entry shall be initialed and dated. These records are subject to audit or review and therefore must not only be complete and accurate, but must be in such condition that they may be clearly and easily followed and understood by people who are unfamiliar with the project.

Every item in the contract must have written data to support payment. Occasionally items that include removals or similar situations where a lump sum is provided do not have sufficient documentation to prove that the item of work was actually accomplished. Make a set of notes for each item of this type.

16.03 Payment for Materials on Hand

Materials which are approved and accepted by the engineer for advance payment must be delivered and stored on the project, or in some other place approved by the engineer. Allowances may be made in the progress estimate for the net cost of such materials, providing that these materials meet the specification requirements in all respects and are intended to become a permanent part of the installation. All payments made for materials furnished shall be based on the contractor's written request after verification by the Materials Department. In some cases the Resident Engineer may perform his own materials certification.

In those cases where it is not practical for the Resident Engineer or his forces to verify quantity, quality, and proper storage, a copy of the Contractor's request should be sent to the Materials Division for action.

The maximum payment should be such that when the estimate of placing and other remaining costs of the work are added, the contract price is not exceeded. The purpose of this instruction is to prevent payment of more than the contract price for the materials and to leave sufficient funds in the item to complete the work in cases where the bid price does not reflect the true cost of work. In no case should payment be allowed for materials that do not conform to the specification requirements.

The following list is provided as an aid in interpreting Section 09.07 of the Standard Specifications and otherwise defining payment for materials on hand.

(a) The words "at the discretion of the engineer" means that approval is based on specification material and a written request from the contractor. Approval is usually secured through the Division Engineer from the District Engineer.

(b) "Advance payment shall not be made unless requested by the contractor" means the prime contractor must make a written request. Subcontractors may initiate the letter but it must be endorsed by the prime contractor.

(c) Certified copies of paid freight bills and invoices shall be submitted to the engineer for any material not produced by the contractor.

(d) The contractors actual cost may be allowed for material produced by him, except concrete aggregates, providing the cost is properly justified and documented. The allowance shall not exceed 50% of any contract unit price.

An allowance for stone chips and cover material shall not exceed that stipulated in Article 09.09.

The allowance for plant mix aggregate may be the actual documented cost but may not exceed $1.50 per unit. This allowance includes haul.

(e) Allowances for any materials should not be made if the material will be used or placed within 60 days.

(f) Advance payment does not relieve the contractor of any responsibility whatsoever for the final quality of the materials in place.

16.04 Payment for Excess Material

Section 09.09 allows payment for excess material crushed out. This involves cover material and stone chips. No other items are listed in the specifications for allowance for payment for excess material. If the contractor does not neglect to dispose of the material at the scheduled prices in the specifications the material will remain the contractor's property and it must be removed from State premises.

The engineer must ascertain the proper quantities that have been used and must be assured that payment made for excess materials does exactly describe the quantity of excess material to be paid for. Notes should be made to effectively document this payment. The notebook used to document the quantity of material should show the estimated number by which the contractor was paid for the excess material purchased by the State.

16.05 Eliminated Items

Occasionally items in the proposal may be found unnecessary for the proper completion of the work. Should such items be eliminated from the contract, their elimination must be documented on a change order in accordance with Article 09.05 of the Standard Specifications. The change order should describe in detail the item to be eliminated and any reimbursement for actual work done and costs incurred including mobilization of materials. No allowance shall be made for anticipated profits.

16.06 Estimates - Progress, Semi-Final and Final

(A) General

The correctness of the payment to the contractor is dependent upon the accuracy of the engineer's estimate of work done as recorded on the estimate sheet. It is up to the engineer making the estimate to assure that the recorded figures truly represent the engineer's estimate and are free from any errors.

If the engineer checks the progress estimate being prepared against the one for the previous pay period, he will minimize the number of errors occurring. Estimates are the basis of all payments to contractors, and should be very thoroughly checked in the field before being submitted to the Division. The Division should again thoroughly check the estimates before they are submitted to the Construction Division in Helena.

The cover letter for progress estimates should contain information for each project regarding overruns authorized by the Division Engineer but not documented by change order or Extra Work Order. the following information is required:

(1) Amount of overrun authorized but not documented.

(2) The total to date of such overruns

This information will help to avoid financial problems created by contract overruns.

(B) Documentation

All estimate quantities, project splits and monies must be broken and subtotaled in the same manner as the items appear on the detailed estimates.

The Accounting Division has estimates photographed and reproduced rather than retyping estimates onto the claim form as was done in previous years. Estimates made with hard pencils, blue ballpoint pens, or with typewriters having worn out ribbons do not make readable reproductions. Therefore, it is requested that field personnel use soft lead pencils, black ink, or typewriters with good ribbons.

Each project, due to differences in complexity, requires a different method of documenting estimated or lump sum pay quantities used on the progress estimates. Since no rigorous system has been established, the Resident Engineer may make up his own methods of providing documentation for estimated quantities, lump sum quantities, etc. However, in order to minimize back tracking, loss of scrap paper work sheets, and misplaced or discarded records, a work sheet should be used as described below to aid in the documentary process.

1. Uniform work sheets similar to the example FIGS,II-7 and 7a will be provided to each engineer in charge of a contract for use in:

    a. Computing or estimating the quantity of work accomplished or percentage payment allowed on lump sum items, such as unclassified excavation, borrow, overhaul, subgrade compaction or similar items, for which notebooks, weigh tickets or similar standard methods of recording daily work progress are not normally kept.

    b. Adding the quantities (a tape attached to the work sheet will also suffice) of culvert excavation, linear feet of pipe installed, number of signs installed, aggregate placed, water applied or similar items which do have notebooks, weigh tickets, punched cards or similar methods of recording daily progress.

2. The work sheets will be retained in the Resident Engineer's file with a copy of that months' progress estimate. A 3-ring notebook with tabs for each month serves this purpose quite well. However, any binding system allowing reasonable access to the records and which properly retains these records is acceptable.

3. The blank spaces in the work sheet heading are for the item number and description, and for your figures in estimating the work accomplished, totals for last months, this month, and total to date. When the computations for an item are complete, place a double line across the page before estimates for the next item are started.

4. It is unnecessary to list, on the work sheet, every item appearing on the monthly estimate since the various notebooks will contain many of these computations. However, documentation must exist either by the work sheet or the notebooks.

Work sheets then will document computations not appearing in the notebooks, notebooks will contain the remaining documentation of quantity calculations and the progress estimates will serve as a continuing summary of monthly payments made.

5. Documentation for HB 42 and HB 436 Expenditures. Documentation may vary as necessary to cover expenditures on each contract. For instance, a visual inspection may determine that a certain number of miles of street or road have been scaled and covered; a copy of the suppliers invoice is sufficient documentation for oil deliveries or similar purchases, a letter of certification from the City or County Engineer can verify aggregate quantities or possibly a rough stockpile measure will be evidence that a quantity is substantially correct. A copy of the documentation should be retained and submitted along with the Final Estimate.

(C) Preparation

Figure II-8 shows an example of a completed final estimate which also shows the important features of a progress estimate. Headings not preceded by an asterick shall be completed by the field except, when the work "to" on the fourth line will be left blank when submitting the final. Semi-final estimates will date from the date of the last estimate to completion date. Do not submit a semi-final if earnings are less than $500.00. Instead send a memo stating the situation.

Each project requires a separate estimate even though the project is included with other projects under one contract. Progress estimates shall be submitted only on designated estimate date as shown in Section 16.06(E) of this manual. Progress estimates shall not be submitted when earnings are less than Five Hundred ($500.00) Dollars. When earnings are less than Five Hundred Dollars ($500.00), a memorandum stating that situation must be submitted. On progress estimates, only those items which are being worked on need be shown. Once an item is shown, it must be carried on subsequent estimates. When the total items are few, use the back side of the estimate form.

In the event of a winter shutdown within an estimate period, the estimate interval will end on the date of the designated estimate period. On resumption of work and submission of estimates the period would extend from the day after the last estimate.

The project agreement estimate must be followed in its entirety except for items not included in the contract. When "work by agreement" replaces a contract item, the original item number, price and quantity are not to be shown on the estimate.

Payment for additional work should be made on the estimate after the work has been accomplished. State the additional work order number on the line with the item, to assist in processing.

All materials taken over from the contractor on completion of a contract shall be shown on the final estimate. Make the proper charge to the maintenance or construction stores account if that item is chargeable to an existing stores account number. A new account number will be assigned by the respective division if the commodity is one for which no stores account is assigned. There should be no surcharge paid the contractor for handling unless he is requested to remove the material to the site of the maintenance stores; then he will be paid 5% of the invoice price for actual cost supported by records necessary for audit. Invoices must accompany the final estimate for materials other than those produced by the contractor. All the material taken over from the contractor after completion of the contract will be shown as a non-participating item. If the commodity is gravel, the stockpile number is to be shown on the final estimate. Form 158 is to be completed and submitted to the Maintenance Department in Helena to show quantities taken over (three copies are necessary).

All figures should be clear, legible and checked for placing of the decimal point.

All final estimates after submittal to the Division Office or District Office shall be checked by personnel other than the project personnel who prepared the final. Checking should be accomplished by and under the direction of the Division Office Engineer.

The project diary shall be continued and maintained by the responsible person doing the checking of the final estimate until the final is completed.

When making an allowance on the estimate for materials placed in storage, no item number should be used until the materials are in place. Do not use a figure under the quantity column. Under the unit column show pounds, linear feet, tons, each, etc. Under the description column, place the name that described the material, such as, structural steel, bridge rail, crushed gravel, etc.

(D) Checking Final Estimate Data

The following outline is being furnished to help field personnel in preparation and checking of all data relating to Final Estimates and to try and devlop uniformity throughout the State. See Figure II-8c.

FIELD NOTE BOOKS & DIARIES

1. All pay items must be properly documented

   (a) Notes are required on every item of work for which payment to the contractor is being made. These notes should include all pertinent information such as stationing, measurements (be it tons, cubic yards, lump sum, square yards, pounds, each, etc.), dates of installation, names of crew personnel, such as staking party, inspector, recorder, tester, scaleman, checker, etc.

   (b) Acceptable signatures and initials.

2. Adding machine tapes should be run on all items that include many entries, such as water, rolling, gravel and oiling notes, etc. The tapes may be attached to notes

involved or wrapped around the packages of tickets or cards, whichever is used as the original source document. Tapes should include proper identification, such as project, date, item involved, etc.

3. Each notebook should be indexed to show what items are included in the book and on what page or pages it may be found. Summaries should be prepared at the end of each pay item in the book, not one summary at the end of the book. For example, a notebook containing surfacing items which may entail four gravel items and three bituminous asphalt items should have a total of seven summaries throughout the book, whereas a notebook containing culvert items would have one summary to include all sizes of culverts, excavation, backfill, etc.

4. All lump sum items or items with "each" units must be supported by notes. Too often notes submitted for items such as removal of miscellaneous items, clearing and grubbing, etc., do not show enough information to properly show the work as being accomplished. Notes for these items of work should show date work started, a brief resume of equipment or methods being used, date work completed, name of inspector, amount involved in lump sum payment in $0.00, etc. If the item of work was accomplished during a period of time involving several estimate pay periods, the notes should indicate amount estimated and how estimated for each pay period to accumulate a 100% complete item.

5. On projects with roadway and structures included in the same contract, it is desirable that the roadway and structure notes be compiled and bound in separate books because the notebooks are filed separately in the Helena Headquarters. It is also desirable that the books be bound using string rather than paper fasteners. String makes future use easier because the pages lie flat when opened.

6. Diaries must have signatures on every page. Pages 2 through 9 must be complete. All items contained in the Detail Estimate must be shown on pages 6 through 9 and all columns completed where applicable. This means that items such as Roadway Material and Railroad Flagging are to be included on Comparison Sheets. All entries in the construction summary are to be entered as they appear on the Detail Estimate according to the appropriate project splits, be it 4-Lane, 2-Lane, Rural, Municipal, I, IG, etc. Also to be included in the construction summary of quantities are all items of work covered by Work by Agreement, Extra Work Orders or Supplemental Agreements. It is not necessary to summarize all change orders in this summary if the quantities are included in original contract items.

7. Daily entries should be complete relative to date, weather, engineering personnel engaged, contractor's equipment and personnel and concise account of the contractor's operations and any other pertinent items, such as discussions with landowners, conflicts with traveling public, etc.

8. A construction summary must be included on Page 198 to 200 of the diary, preferably in Diary No. 1.

MISCELLANEOUS SUPPORTING DATA

1. Gravel and Borrow Pit reports (5 copies required in Helena). Use format as outlined in Attachment 2.

2. Mileage comparison (3 copies required in Helena). A mileage comparison is to be made on all projects involving any roadway construction, even though no change in mileage results. No report is necessary on projects involving only fencing, lighting, signing, seeding, etc.

3. Extra Work Orders (6 facsimile and 1 original required in Helena). Supporting data for extra work orders is to include invoices for materials used, a letter from the contractor substantiating labor surcharge rates, health and welfare, and premium on bond. All quantities of labor, equipment and materials are to be maintained on forms provided for extra work, namely Form CSN 12A & B. The reverse side of the final resume of quantities is to be signed by the Division Engineer. It is to be noted that with the use of the CSN 12A & B forms it is not necessary to make a recap of items involved; all that is required is to make a recap on the backside of the extra work order form of total labor, material and equipment, because the notes suffice for the daily recap.

4. Gravel tickets, water and rolling cards, oil certificates, traffic control cards, etc., are to be submitted to Helena in a package or box separate from the other supporting data. This data is to be submitted on all projects except straight Secondary "S" and State Maintenance Projects.

5. Computation sheets for earthwork quantities and overhaul including addtional excavation.

6. Form PR-47 must be submitted for all projects except those designated "S" and "S.M.P.". NOTE: This form should be submitted under separate cover directly to the Construction or Bridge Engineer and should not be held awaiting completion of the Final Estimate.

7. Transit, Level and Grade notes are to be included with the submittal of all quantity notebooks.

WHITE PRINTS & LINEN SUMMARIES

1. All items on white prints must be either changed or checked, including grades, P.I. elevations, pipe stationing, both on plan and profile, as well as pipe sizes and kind (C.S.P., R.C.P., C.A.P.), culvert excavation, additional excavation; e.g. all approaches moved should be replotted with original stationing crossed out. New inlet and outlet ditches and ditch blocks should be plotted on as built prints. On

fencing projects, all new fencing topography, such as panels, cattleguards, etc., should be plotted on the white prints.

2. All changes on plan sheets must be clearly legible, either with red ink or a sharp red pencil for road projects.

3. Each sheet must be initialed by the individual making the changes and the checker.

4. Summaries of road construction quantities are to be made on linen sheets. All items appearing on the Final Estimate should be placed on linens.

5. All Extra Work Orders and Work By Agreement change order items must be entered on the linen summary as well as lump sum items. These entries should have description of work and cost.

6. As built construction plans and summaries must agree completely with field notes, final estimate and comparison sheets.

7. Corrected quantities must be shown below all typical sections, together with gravel and oil weights. Also new typical sections are to be drawn for any major change in design covered by Change Order.

8. Linen summaries must be neat and clearly legible with lettering done by free hand or lettering guide.

COMPARISON SHEETS & EXPLANATORY NOTES

1. Every item on the project agreement must appear on the comparison sheet.

2. Compute overrun or underrun quantities between project agreement and final and enter in proper column.

3. All change orders must be shown on the comparison sheet.

4. All extra work orders are to be shown on the comparison sheet in money amounts.

5. Change orders covering overruns or underruns must be shown by number and quantities with + or - sign for all items to which they apply.

6. Explanatory notes must be prepared for all significant overruns or underruns, and must be clear, concise and completely explain the actual reason for same. If a change order is issued and approved, and later found not needed, an explantory note should be made.

7. Lump sum items, such as Structural Steel, Traffic Control and Roadway Material, should be shown in both decimal and money amounts.

8. When the project agreement includes Railroad Flagging, this item is also to be shown on the comparison sheets. Note: In those cases where the final billing has not been received at the time of submittal, leave the final column blank. It is also suggested that the Helena Headquarters be advised as to what action has been initiated by the Division Office in regards to obtaining the final bill from the railway company.

PREPARATION OF THE ESTIMATE FORM 14

As in the past, the Helena Office will continue to prepare and issue a supply of pre-printed estimate forms for use as progress and final estimates on most projects. On projects where it is expected that only one or two estimates will be prepared, we will not make a supply of pre-printed forms.

Entries to be completed by field personnel

Final Estimate

Fill in: Estimate No.__________ - designate if Final

From Date________ - Date of Contract Award - See Const. Memo. No. 6-68 (attachment 3)

Actual Completion Date

Number of Days Used

Date Certified Complete by District Engineer

Quite often the contractor will request that the State take over certain extra or unused materials such as aggregate stockpiles, unused culvert material, etc.

If such items are taken over, it is appropriate to pay for them on an estimate at the time taken over and not necessarily on the Final Estimate. When these items are placed on an estimate, appropriate stores account charge numbers are to be indicated and a Form No. 158 should be prepared and submitted with the estimate. Items of material taken over that were obtained from commerical suppliers must have invoices submitted to document the unit prices being paid. For items taken over, that were produced by the contractor, an adequate cost breakdown must be submitted. Exceptions to this would be items that are presently covered in the Standard Specifications such as excess cover material or stone chips. See Article 09.09.

NOTE: If during the couse of checking of the Final Estimate, quantities are found to be worth $500.00 or more, a semi-final or if necessary, a revised semi-final, must be submitted. Semi-final estimates will date from the date of the last estimate to the completion date. Revised Semi-final estimates will be dated showing the completion date as both the from and to dates.

Rev. 5-1-70

(E) Supporting Data for Final Estimates

All necessary data that supports final payment must be thoroughly and accurately checked in the Division Office before its submission to the Helena Construction Office. Weigh tickets, punched cards and similar daily-kept information should be completely checked for completeness, signatures and authenticity.

Comparison Sheets & Explanatory Notes (Refer to Figure II-9 for example)

1. Each item on the detail estimate must appear on the comparison sheet accompanying the final estimates and requires only the comparison of final quantities shown on the detail estimate. If a change order is issued and approved but later found not needed, an explanatory note is required.

2. All utilities and extra work orders will be carried on the comparison sheet in money amounts.

3. Explanatory notes covering overruns and underruns must be clear and concise and completely explain the actual reason for the overrun or underrun. See Figure II-9a.

4. The PR-47, when required, is to be submitted separately to the Construction Engineer or Bridge Engineer. The Form PR-47 is not required on those projects designated as Secondary. Do not confuse the "S" designation with projects carrying the designation S-US or US.

5. Six (6) facsimile copies and one approved original of each extra work order must accompany the final estimate. Five (5) copies of the gravel reports will accompany the final estimates.

This report should list all sources used for project construction by that description; The ownership; Helena Laboratory numbers, if any; The original quantity in cubic yards; The quantity removed; and the quantity remaining. Include the conversion factors of the various type of materials. The report should state if the sources are exhausted. (See Figure II-9b).

This report applies to sources selected for the borrow base course, all aggregates used in the surfacing course, and to designated borrow sources when additional right-of-way has been purchased to obtain such borrow.

6. Submit three (3) copies of a mileage comparison with the final. A milage comparison is necessary even though no mileage change occurred.

7. Summaries of road construction quantities are to be made on linen sheets. All changed on bridge projects shall be made in red ink, on a set of white prints and submitted with the final estimate for those bridge projects.

8. As-built construction plans must agree completely with the

construction notes, summary sheet, final estimate and comparison sheet in respect to quantities, lengths, stationing, changes in grade, elevations, changes in materials, etc. Construction changes on white prints are to be made in red.

9. The construction diary is to be filled out in its entirety. This includes pages 6 through 9 and pages 198 to 200, which is the construction summary.

Linen sheets submitted with the final are filed in Helena as a permanent record and must be prepared in a neat, well-lettered fashion. Free hand lettering that is neat is acceptable, as is mechanical lettering.

All columns of entries or quantities on weight tickets should be added on adding machine rather than calculators. The adding machine tape can then be initialed and preserved as a permanent record of the computations.

It is very important that final pay quantity calculations books contain the initials with dates of the person who made the entries and the person who checked the entries wherever any calculations, sketches, notes, headings, indexes, summaries, etc., appear.

(F) Submittal Data

The following estimate period has been established for each Division for submittal of progress estimates to the Helena Construction Office.

Divisions	Estimate Period
Missoula - Kalispell	1st of the month
Butte - Bozeman	5th of the month
Great Falls - Havre	10th of the month
Glendive - Wolf Point - Miles City & Lewistown	20th of the month
Billings	25th of the month

All estimates submitted shall consist of the original and one carbon copy. All signatures will be the original not the carbon.

All estimates--progress, semi-final and final--with its supporting data should be mailed directly to the Construction Division, Helena. The final estimate should not be included in the same package as the supporting data, but should be transmitted under separate cover. Keep gravel tickets and cards in the Division files.

The final estimate is not to be held in the Division Office until receipt of final billing from utility companies before submittal to Helena. A note to the affect that billing has or has not been received on the comparison sheet of the final will be sufficient.

All final estimates must be in the Division Office no later than thirty (30) days after the completion date of the project as is shown on the certification of completion unless an extension in writing is granted by the District Engineer.

A semi-final estimate will be prepared and transmitted separately in all cases, except when earnings are less than $500.00.

Progress estimates for HB 42 funds should be submitted monthly if requested by city or county officials.

(G) Progress Estimates for Work or Material Purchases with HB 42 or HB 436 Funds.

The Division shall prepare progress estimates in favor of the contractor or supplier, (no payments are made direct to the city or county), as required by the amount of work completed or material delivered and submit in the regular manner, as simply as possible.

Progress estimates for HB 42 and 436 funds should be submitted monthly if requested by city or county authorities.

Special attention should be given to the State-City or County agreement which will show the availability of funds to be expended so that the estimate is not made up for more money than has accumulated in the city or county account. Some allocations are small and the agency may elect to spend them as they accumulate monthly.

16.07 Acceptance and Final Payment

Article 09.08, Acceptance and Final Payment, in the Standard Specifications, describes the sequence of events, time periods for filing claims, and other information necessary before a final acceptance can be granted for any construction contract. The Resident Engineer should pursue his computation of quantities, preparation of the notebooks and checking of the various information, so that when the "certificate of completion" has been written and submitted, it will only be a short time before the final estimate and all supporting data is submitted.

The certificate of completion must be in the Construction Office prior to Monday noon of the week of the regularly scheduled monthly meeting of the Highway Commission.

The Standard Specifications do not prescribe payment of interest due on final monies earned by the contractor. It is therefore urged that a concerted effort be made to submit the final estimate and supporting data to the Division Office within thirty (30) days after completion of a project. Payment of interest rates may be forestalled by prompt preparation and submittal of the final estimate.

The contractor may submit a written request for release of a portion of the retained amount whenever a project is substantially completed, and only minor items or such items of work as cannot be accomplished for several months exist. Normally the State Highway

Engineer will approve the recommendation for such a release providing: Both the project and the contractor are in good condition and good standing; That there are no claims or liens filed against the contract; and the contractor remits payment for his current diesel fuel contractual obligations and labor compliance is current. The contractor must obtain and submit consent of his surety before release of any portion of the retained amount can be made.

Submittal of the form, Certificate of Completion of Construction Contract, will be sufficient notice of actual project completion. If a delay is necessitated in submitting the certificate of completion, the Division Office shall notify the Construction Office by teletype of the project completion and the reason for delay in submitting the certificate. Submit this certificate immediately.

THE COMPARISION SHEET & EXPLANATORY NOTES

Figures II-9 and II-9a are examples of the Comparision Sheet and Explanatory Notes for your guidance in completing the full listing used for each project. These examples contain only a small portion of the items that will actually be used, by they have been selected to show what words and numbers are to be placed in each column of the Comparison Sheet, for a good description, and what values are to be explained in the Explanation Notes.

For instance, where a Change Order has been used to cover an overrun or underrun, this notation, under the Explanation column of the Comparision Sheet, is sufficient. Further description of the change, in the Explanatory Notes, is unnecessary unless there were changes not covered by the Change Order. This condition exists for item number 5210, as shown on the Comparison Sheet Figure II-9.

Gradual changes often accumulate during the work, that cause no alarm and are acceptable (without justification by Change Order). Sometimes such changes will be a sizable quantity, similar to what occured with Overhaul Item 1201 on the Comparison Sheet. The explantory notes indicate that knowledge of a possible overrun was available when the work happened, but the actual magnitude of the overrun could not be reasonably estimated early in the work. Naturally, the Division Engineer and B.P.R. Area Engineer would have been told of this problem and a decision made, whether to initiate a Change Order or not. In this instance, it is permissible to explain the change in the Explanatory Notes.

Changes that are negligible really need no further explanation than the statement "Negligible" placed in the explanation column of the Comparison Sheet as shown for item number 4014.

Lump sum items like items 9885 and 43511, should show the actual money amount involved in the lump sum. The number "1" alone has no meaning in a comparison, unless the actual quantity used is also listed.

Sometimes changes in the planned work are anticipated, a Change Order prepared and approved and then no actual increase or decrease in the work or its quantities would occur. An example of this is when the unclassified excavation quantities in one balance appear to be overrunning considerably. A Change Order is made and approved but then as the work progresses, other balances underrun enough to offset the originally anticiapted overrun. Change Orders similar to the above example do require an explanation even though the anticiapated conditions do not happen or only a very small part of the change ordered work is used.

16.08 HB 42 and HB 436 Agreements

It is the desire of the Highway Commission to process agreements and payments based on HB 42 Funds as simply as possible and still have an adequate measure of control that these funds are being used properly.

No funds are being reserved for the purpose of inspections or administration, (except in special cases where extensive Engineering is required and funds will will be programmed for this specific purpose) and the costs thereof are being absorbed in our general administration costs. Therefore, inspection will be kept to a minimum required to insure that the work has been done or that the quantities are in the ball park when no other measurement has been made.

The following procedure and responsibiluty shall govern the processing of Hb 42 Fund agreements with Cities and Counties.

1. Copies of the bid for work to be done or quotations of materials to be supplied will be approved by the State Highway Engineer. Copies of this approval will be sent to the field office.

2. Upon receipt of approval the fiedl will issue written authorization, to the city or county, to proceed with construction or delivery.

3. The field shall notify the Construction Engineer when work actually begins.

4. The Division shall prepare progress estimates in favor of the contractor or supplier, (no payments are made direct to the city or county), as required by the amount of work completed or material delivered and submit in the regular manner.

   Documentation may vary as necessary. For instance, a visual inspection may determine that so many miles of street or road have been sealed and covered, a copy of the suppliers invoice is sufficient to document oil deliveries or similar purchases, a letter of certification from the City or County Engineer can verify aggregate quantities or possibly a rough stockpile measure will be evidence that a quantity is substantially correct. A copy of the documentation should be retained and submitted along with the Final Estimate.

Special attention should be given to the State-City or County agreement which will show the availability of funds to be expended so that the estimate is not made up for more money than has accumulated in the city or county account. Some allocations are small and the agency may elect to spend them as they accumulate monthly.

5. The field shall notify the Construction Engineer when the work has been completed by submittal of a completion certificate. The standard form used by the State is sufficient by filling in the applicable blanks.

6. The Division shall prepare a Final Estimate and submit it to the Construction Engineer along with supporting documentation.

PROGRESS ESTIMATE WORK SHEET

PROJECT NO. I-IG 90-2 (14) 105, U1

COMPUTATIONS BY EWS

MONTH AUGUST

EST. NO. 3

SHEET NO. 1 OF 2

ITEM NO.	DESCRIPTION - COMPUTATIONS - APPROXIMATIONS THIS MONTH	QUANTITY
1101	UNCLASSIFIED EXCAVATION	
	I MUNICIPAL	
	BALANCE 520 - 560 - 40% COMPLETE x 15,000 = 6000 CU.YD.	
	TOTAL TO DATE = 6000	
	TOTAL LAST ESTIMATE = 0	
	TOTAL THIS ESTIMATE = 6000 CU.YD	6000 CU. YD.
	I RURAL	
	BALANCE 0+00 - 30+50 100% x 87,310 = 87,310 CU.YD	
	30+50 - 52 100% x 50,000 = 50,000	
	52 - 97+50 100% x 250,000 = 250,000	
	97+50 - 110 100% x 130,000 = 130,000	
	110 - 125 70% x 50,000 = 35,000	
	125 - 142 60% x 80,000 48,000	
	TOTAL TO DATE = 600,310	
	TOTAL LAST ESTIMATE = 412,310	
	TOTAL THIS ESTIMATE = 188,000	188,000 CU.YD.
1213	OVER HAUL UNCLASSIFIED BORROW	
	I RURAL	
	BALANCE 0+00 - 30+50 100% x 15000 = 15000 CU. YD.	
	52 - 97+50 100% x 4000 = 4000	
	125 - 142 50% x 8000 = 4000	
	TOTAL TO DATE = 23,000 CU YD	
	TOTAL LAST ESTIMATE = 0	
	TOTAL THIS ESTIMATE = 23,000 CU. YD	23,000 CU.YD.
	IG RURAL	
	BALANCE 372+50 - 397+00 100% x 27,000 = 27000 CU.YD.	
	TOTAL TO DATE = 27,000	
	TOTAL LAST EST. = 0	
	TOTAL THIS EST. = 27,000 CU.YD.	27,000 CU.YD.

Figure II-7

PROGRESS ESTIMATE WORK SHEET

PROJECT NO. I-IG 90-2(14) 105, 111

COMPUTATIONS BY Ews

MONTH AUGUST

EST. NO. 3

SHEET NO. 2 OF 2

ITEM NO.	DESCRIPTION - COMPUTATIONS - APPROXIMATIONS THIS MONTH		QUANTITY
1161	CULVERT EXCAVATION		
	I MUNICIPAL		
	SEE NOTEBOOK NO. 6 FOR DETAILS	9 CU. YD.	
		15	
		10	
		11	
	TOTAL TO DATE =	45	
	TOTAL LAST EST. =	0	
	TOTAL THIS EST. =	45	45 CU. YD.
	I RURAL		
	SEE NOTEBOOK NO. 6 FOR DETAILS	50 CU. YD.	
		20	
		17	
		13	
		40	
		33	
		17	
		32	
		18	
		57	
		20	
		33	
		47	
		12	
		21	
		10	
	TOTAL TO DATE =	440	
	TOTAL LAST EST. =	403	
	TOTAL THIS EST. =	37	37 CU. YD.
	IG RURAL		
	SEE NOTEBOOK NO. 6 FOR DETAILS	15 CU. YD.	
		13	
		17	
	TOTAL TO DATE =	45	
	TOTAL LAST EST. =	0	
	TOTAL THIS EST. =	45	45 CU. YD.

Figure II-7a

PROJECT AGREEMENT ESTIMATED QUANTITIES						CONSTRUCTION QUANTITIES								
ITEM No.	QUANTITY	UNIT	DESCRIPTION	UNIT PRICES		TOTAL LAST ESTIMATE		TOTAL THIS ESTIMATE		TOTAL TO DATE		AMOUNT		
				DOLLARS	CENTS							DOLLARS		CENTS
TRAFFIC SIGNS														
TYPE CODE Y002														
	2 LANE - RURAL - FA=91.21%													
8809	7	Each	Mile Posts	20	00	7		0		7			140	00
8810	110.4	Sq.Ft.	Sheet Aluminum Signs	6	00	110	4	0	0	110	4		662	40
8814	15	Sq.Ft.	Aluminum Sheet Increment Signs	7	25	15	0	0	0	15	0		108	75
8816	393	Lb.	Steel Structure Sign Posts	0	55									
8817	120	Lb.	Steel U Sign Posts	0	60	120		0		120			72	00
8821	0.056	MBM	Treated Timber Posts	1,000	00	0	056	0	000	0	056		56	00
88255	66	Lin.Ft.	Treated Timber Sign Poles-CL5	2	50	66		0		66			165	00
9046	298	Each	Design A Guide Posts	4	75	298		0		298		1	415	50
9049	4	Each	Design D Guide Posts	10	00	4		0		4			40	00
			WORK BY AGREEMENT											
CO#11		Lb	Steel Structure Sign Posts	0	80	415		0		415			332	00
CO#11		Each	Timber Post & Pole Slots	9	22	4		0		4			36	88
CO#12		Lin.Ft.	Steel Guard Rail Conc. Posts	5	60	8,900		0		8,900		49	840	00
CO#12		Each	Concrete End Anchors	191	60	7		0		7		1	341	20
										SUB-TOTAL:		54	209	73
			Material Taken Over From the Contractor											
			NON-PARTICIPATING											
		Charge No. 4320-8943-12-01-01-1300												
		Ton	3/4" Type "A" Cr. Top Surfacing	1	022	0	00	2,016	07	2,016	07	2	060	42

FA = 91.21%	No. 1	126" Vehicular Underpass 10 Ga. Sta. 1540+00	9	133	71
EXTRA WORK ORDERS	No. 2	Placement of Asphaltic Membrane, Sta. 1416+00 to Sta. 1651+00	72	286	81
	No. 3	Placing of 12" x 80' Perforated C.M.P. at Station 1420+80		934	43

*Estimated Total Participating Cost________

*Estimated______% Complete as of________

*Estimated Value of Work in Place________

Total Earned to Date	1	137	521	15
*Amount Retained			NONE	
*Deductions			—	
*Total Amount Due	1	137	521	15
*Previous Allowances	1	130	573	82
*Amount Due This Estimate		6	947	33

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Form 14—20M—2-61—30203

State Highway Commission of Montana

Helena, Montana

( ) Progress
( ) Semi-Final
(x) Final
ESTIMATE

MONTANA HIGHWAY COMMISSION
RECEIVED
MAY -6 1968
HELENA, MONTANA

Estimate No. 17 FINAL

Division No. 43 - 12

For Period From APRIL 27 19 66,

To March 11 19 68, Inclusive

Contractor Joe Mayo & Son, Inc.

Address P. O. Box 310
Cavalier, North Dakota 58220

Stipulated Completion Date (Time) 300 Calendar Days

Work Began JUNE 15, 1966

Actual Completion Date OCTOBER 19, 1967

Number of Days Used (If Calendar Days) 300 Calendar Days

Certified Complete by District Engr. OCTOBER 21, 1967

REMARKS:

Project No. I 94-3 (12) 76 U-1

Name Rosebud County Line - East Road

County Rosebud

Project Agreement Estimate Dated April 26, 1966 Letting Date
April 27, 1966 Award Date

* Accepted by Commission October 25, 1967

* Accepted by B.P.R. March 11, 1968

* P.S. & E. Approved by B.P.R.________

APPROVED
FOR PAYMENT
BY Eugene W. Stettler
CONSTRUCTION ENGINEER
DATE JUL 1 9 1968

Certified as to Quantities of Work, Price and Extensions.

Resident Engineer Date: 3/18/68
(Name) (Title)

Kenneth Papps Date: 5-2-68
(Div. Engr.)

C.R. McBee Date: 5-3-68
(Dist. Engr.)

Date Received in Div. Off. 3/18/68

Date Received in Const. Off. MAY 6 1968

Date to Acct. JUL 1 9 1968

Sherman Blatts

Two copies of this form required by Helena (Original and 1st carbon)
*To be left blank.

Figure II-8

PROJECT AGREEMENT ESTIMATED QUANTITIES						CONSTRUCTION QUANTITIES								
Item No.	QUANTITY	UNIT	DESCRIPTION	UNIT PRICES		TOTAL LAST ESTIMATE		TOTAL THIS ESTIMATE		TOTAL TO DATE		AMOUNT		
				DOLLARS	CENTS							DOLLARS		CENTS
UNIT 1 - GRADE, AGGREGATE SURFACE, PLANT MIX BITUMINOUS SURFACE & DRAIN														
TYPE CODE 6201														
	2 LANE - RURAL - FA=91.21%													
	BASE BID													
1101	1,019,002	Cu.Yd.	Unclassified Excavation CO#16	0	22	1,044,487		0		1,044,487		229	787	14
1106	1,086,805	Cu.Yd.	Roadbed Compaction	0	05	1,080,610		0		1,080,610		54	030	50
1201	457,955	Mi.Yd.	Overhaul Unclassified Excavation	0	10	411,891		0		411,891		41	189	10
1260	358	Mi.Yd.	Haul Binder	0	20	213		0		213			42	60
1302	1,626	Unit	Roll Surface Courses CO#13	9	00	2,287	9	0	0	2,287	9	20	591	10
1352	7,594	M.Gal.	Water Surface Courses	2	50	6,178	6	0	0	6,178	6	15	446	50
1601	835	Hour	Motor Grader	13	00	276	50	0	00	276	50	3	594.	50
1605	1,480	Hour	Scraper - 12 Cubic Yard CO#5,9,10	18	00	1,157	16	0	00	1,157	16	20	828	88
1611	57	Hr.	Road Leveler Operations CO#16	25	00	66	00	0	00	66	00	1	650	00
1635	1.0	F.A.	Traffic Control	3,000	00	0	372	0	000	0	372	1	116	00
2001	179	Cu.Yd.	Binder	0	50	159		0		159			79	50
2312	193,715	Ton	2½" Type A Base Course	0	54	192,645		0		192,645		104	028	30
2314	74,289	Ton	1½" Type A Base Course	0	57	52,436		0		52,436		29	888	52
2411	27,452	Ton	3/4" Type A Top Surfacing	0	89	25,862		0		25,862		23	017	18
2414	376	Ton	3/8" Type A Top Surfacing	4	80	129	2	0	0	129	2		620	16
2422	8,316	Ton	3/4" Type B Top Surfacing	0	93	7,842		0		7842		7	293	06
3013	38,695	Ton	Type 3 Plant Mix Bituminous Surf.	3	76									
3050	387	Ton	Mineral Filler	17	00	265	58	0	00	265	58	4	514	86
31065	19,171	Gal.	SS-1 Emulsified Asphalt	0	16	5,211		0		5,211			833	76
3114	2,321.85	Ton	100=120 Asphalt Cement	22	00	2,054	49	0	00	2,054	49	45	198	78
3136	244.75	Ton	MC-70 Liquid Asphalt	38	00	240	26	0	00	240	26	9	129	88
4014	20.8	Cu.Yd.	Class DD Concrete	150	00	20	759	0	000	20	759	3	113	85
5011	1,708.8	Cu.Yd.	Type A Random Riprap	7	00	1,701	8	0	0	1,701	8	11	912	60
5023	9	Cu.Yd.	Gravel Riprap	5	00	6	6	0	0	6	6		33	00
5210	2,483	Cu.Yd.	Culvert Excavation CO#2	1	75	2,145	3	0	0	2,145	3	3	754	28
5410	1,026	Cu.Yd.	Bedding Material CO#2,CO#16	3	00	1,193	5	0	0	1,193	5	3	580	50
5416	100	Lin.Ft.	Relay Pipe Culvert	2	00									
55301	120	Lin.Ft.	24" CSP Culvert-16G-Type A Bitum.	6	80	120		0		120			816	00
59704	328	Lin.Ft.	144" SSPP Culv.-1G-Type D Bitum.	130	60	328		0		328		42	836	80
6011	116	Lin.Ft.	6'9" SSPP Arch Culvert - 12G	38	35	116		0		116		4	448	60
6119	124	Lin.Ft.	180" SPP Vehicular Underpass-8G	120	30	124		0		124		14	917	20
62232	1,188	Lin.Ft.	24" RCP Culvert - CL2	8	10	1,188		0		1,188		9	622	80
62233	152	Lin.Ft.	24" RCP Culvert - CL3	8	15	152		0		152		1	238	80
62235	172	Lin.Ft.	24" RCP Culvert - CL5	10	80	172		0		172		1	857	60
62352	184	Lin.Ft.	36" RCP Culvert - CL2	15	85	184		0		184		2	916	40
62353	134	Lin.Ft.	36" RCP Culvert - CL3	16	60	134		0		134		2	224	40
62354	154	Lin.Ft.	36" RCP Culvert - CL4	18	15	154		0		154		2	795	10
62382	86	Lin.Ft.	42" RCP Culvert - CL2	20	50	86		0		86		1	763	00
62442	234	Lin.Ft.	54" RCP Culvert - CL2	31	65	234		0		234		7	406	10
62445	172	Lin.Ft.	54" RCP Culvert - CL5	45	70	172		0		172		7	860	40
7509	7,050	Lin.Ft.	Bituminous Curb	0	50	7,050		0		7,050		3	525	00
82240	4	Each	24' Cattle Guard	1,500	00	4		0		4		6	000	00
8345	100	Rod	Remove Fence	1	50	72	0	0	0	72	0		108	00
8347	100	Rod	Temporary Fence	3	00	72	0	0	0	72	0		216	00
90160	12,725	Lin.Ft.	Steel Guard Rail-Concrete Posts	2	72									
9046	4	Each	Design A Guide Posts	4	75									
9406	298	Lin.Ft.	Embankment Protector	12	00	298		0		298		3	576	00
9610	2	Each	Project Marker	30	00	2		0		2			60	00
9620	38	Each	Station Markers	10	00	38		0		38			380	00
9630	69	Each	Right of Way Monument	8	00	68		0		68			544	00
	ALTERNATE A													
5530	372	Lin.Ft.	24" CSP Culvert - 16G	6	00	372		0		372		2	232	00
			WORK BY AGREEMENT											
CO#5,10		Hours	Use of Cat D-8 14A & Dozer	25	18	317	75	0	00	317	75	8	000	95
CO#5,9		Hours	Use of Cat D-9 18A Tractor	24	58	192	00	0	00	192	00	4	719	36
CO#5		Hours	Use of Cat D-9 34A Tractor	27	08	30	00	0	00	30	00		812	40
CO#6		Ton	1½" Type "A" Base Course	0	54	21,935		0		21,935		11	844	90
CO#1		Ton	Type 3 Plant Mix Bit. Surf.	3	66	35,393	7	0	0	35,393	7	129	540	94
										SUB-TOTAL:		907	537	30
	ONE MAJOR STRUCTURE OVER 20.0' SPAN													
	TYPE CODE K 481													
	BRIDGE ENDS: Sta. 1580+44.30 & 1582+23.80													
	2 LANE-RURAL - FA=91.21%													
40121	437.5	Cu.Yd.	Class AD Concrete	85	00	430	10	0	00	430	10	36	558	50
42121	12	Each	40' Prestressed Beam Type A	1,000	00	12		0		12		12	000	00
42131	6	Each	45' Prestressed Beam Type A	1,100	00	6		0		6		6	600	00
42141	6	Each	50' Prestressed Beam Type A	1,200	00	6		0		6		7	200	00
43511	1.0	L.Sum	Structural Steel	300	00	1	000	0	000	1	000		300	00
45101	350	Cu.Yd.	Type 1 Structure Excavation	2	00	297	2	0	0	297	2		594	40
46051	1.0	L.Sum	Treated Timber Test Piles	3,000	00	1	000	0	000	1	000	3	000	00
46101	1.0	L.Sum	Steel Test Piles	3,000	00	1	000	0	000	1	000	3	000	00
46401	1,100	Lin.Ft.	Furnish Treated Timber Piles CO#3	2	00	1,248	0	0	0	1,248	0	2	496	00
46411	1,052	Lin.Ft.	Drive Treated Timber Piles CO#3	1	00	1,147	3	0	0	1,147	3	1	147	30
46471	590	Lin.Ft.	Drive Steel Bearing Piles	3	00	549	3	0	0	549	3	1	647	90
46481	600	Lin.Ft.	Furnish Steel Bearing Piles	5	00	560	0	0	0	560	0	2	800	00
47101	68,012	Lbs.	Reinforcing Steel	0	15	68,009		0		68,009		10	201	35
48101	361.33	Lin.Ft.	Std. Steel Bridge Rail-Type 5	10	00	361	33	0	00	361	33	3	613	30
49101	4	Each	Bridge Drains Concrete Structure	50	00	4		0		4			200	00
										SUB-TOTAL:		91	358	75

Figure II-8a

STATE HIGHWA OMMISSION
Helena, Montana

FEDERAL AID PROJECT NUMBER - I 94-3 (12) 76 U-1
COMPARISON SHEET

Page 1 of ____

Item No.	Description	Unit	Quantities Agreement	Quantities Final	Overrun	Underrun	Change Order No.	Change Order Amount	Explanation
	UNIT 1-GRADE, AGGREGATE SURFACE, PLANT MIX BITUMINOUS SURFACE & DRAIN TYPE CODE 6201 2-LANE-RURAL-FA = 91.21%								
BASE BID									
1101	Unclassified Excavation	CY	1,019,002	1,044,487	25,485		16	+25,522	See C.O. #16
1106	Roadbed Compaction	CY	1,086,805	1,080,610		6,195			See Note #1
1201	Overhaul Unclassified Exc.	M.Y.	457,955	411,891		46,064			See Note #2
1635	Traffic Control	F.A.	$3,000.00	$ 1,116.00		$1,884.00			See Note #6
4014	Class DD Concrete	CY	20.8	20.759		0.041			Negligible
5210	Culvert Excavation	CY	2,483	2,145.3		337.7	2	+86	C.O.#2 & Note #18
5416	Relay Pipe Culvert	LF	100	0		100			Nee Note #19
8406	Embankment Protector	LF	298	298					
9885	Roadway Material	L.Sum	$10,285.00	$11,109.85	$ 824.85				See Note #24
	EXTRA WORK ORDERS								
EWO #1	Vehicular U-Pass-10 Ga.Sta.1540	126"	0	$ 9,133.71	$ 9,133.71		1	$ +9,133.71	See EWO #1
EWO #2	Asphaltic Membrane Sta. 1416 to 1651		0	$ 72,286.81	$72,286.81		2	$+73,495.30	See EWO #2
EWO #3	12"x80' Perf. CMP Sta.1420+80		0	$ 934.43	$ 934.43		3	$ +1,180.21	See EWO #3
	WORK BY AGREEMENT								
CO #1	Type 3 Plant Mix Bit. Surf.	Ton	0	35,393.7	35,393.7		1&7	+36,550	See CO #1 & 7
	ONE MAJOR STRUCTURE OVER 20.0' SPAN TYPE CODE X 481								
	BRIDGE ENDS: STATION 1580+44.30 & 1582+23.80								
42121	40' Prestressed Beam Type A	Each	12	12					
43511	Structural Steel	L.Sum	1.0 $ 300	1.0 $ 300					

FIG.II-9

Division 5230

I 94-3 (12) 76 U-1

EXPLANATORY NOTES

Note No. 1 Roadbed Compaction. Quantities to be compared are: Project Agreement - 1,086,805 cubic yards; Final - 1,080,610 cubic yards. Final quantities underran project agreement quantities 6,195 cubic yards. Payment for this item was made as follows resulting in this entire underrun: Compaction of original ground beneath roadway section - 57,538 cubic yards; material utilized in roadway embankment - 1,016,381 cubic yards; Reservation Creek Road left and right Station 1581+60 - 2,603 cubic yards; deleterious material removed from embankment section Station 1641+00 to Station 1648+48 - 4,088 cubic yards.

Note No. 2 Overhaul Unclassified Excavation. Quantities to be compared are: Project Agreement - 457,955 Mile Yards; Plan - 381,629 Mile Yards; Final - 411,891 Mile Yards. Final quantities overran plan quantities 30,262 mile yards. Of this, 14,314 cubic yards occurred in the balances between 1498+47.6 and 1611+00 due primarily to displacement of natural ground in a swampy area between Stations 1567+00 and 1580+00. The remaining portion of this overrun occurred due to a general overrun of unclassified excavation throughout the project due to the embankment material compacting slightly more than anticipated.

Note No. 6 Traffic Control. Quantities to be compared are: Project Agreement - $3,000.00; Final - $1,116.00. Construction was not open to through traffic, Minimum signing only and no flagging were required causing an underrun of $1,884.00.

Note No.18 Culvert Excavation. Quantities to be compared are: Project Agreement - 2483 cubic yards; Plan - 2320 cubic yards; Final - 2145.3 cubic yards. Final quantities underran plan quantities by 174.7 cubic yards. Culvert excavation for minor pipe at numerous locations overran plan quantities by accumulative amounts totaling 154 cubic yards. However, culvert excavation for a 144" structural plate pipe culvert at Station 1406+20 underran plan quantities by 460 cubic yards resulting in a net underrun for this item.

Note No.19 Relay Pipe Culvert. Quantities to be compared are: Project Agreement - 100 Linear Feet; Final 0 Linear feet. This is an arbitrary quantity included in the bid proposal to establish a bid price. However, none was required on this project.

Note No.24 Roadway Material. Quantities to be compared are: Project Agreement - $10,285.00; Final - $11,109.85. The final amount overran the project agreement amount by $824.85. An additional 16,819 cubic yards of aggregate was secured from optioned sources for special treatment of sections of Bearpaw Shale as described in Extra Work Order No. 2.

FIG.II-9a

STATE HIGHWAY COMMISSION
MILES CITY, MONTANA

FEDERAL AID PROJECT NUMBER I-IG 94-3(13)83 U-1
GRAVEL PIT REPORT

LOCATION OF PIT Adj. North of Sta. 1945+00.0, SW¼, W½W½SE¼, Section 24 Township 6 North, Range 39 East, M.P.M. Rosebud County, Montana.

OWNER OF PIT Leo DeCock, Forsyth, Montana. Obtained by Material Site Agreement. Expiration of agreement, 90 days after completion of the above captioned project. Optioned at royalty of 0.05 per cu.yd.

LABORATORY NO. 303190 - 212

GRAVEL WEIGHT	2½" Type A Base Surf.	3091 lbs. per cubic yard
	1½" Type A Base Surf.	3091 lbs. per cubic yard
	3/4" Type A Top Surf.	2915 lbs. per cubic yard
	3/4" Type B Top Surf.	2857 lbs. per cubic yard
	3/4" Plant Mix Agg.	3001 lbs. per cubic yard

MATERIAL REMOVED FROM PIT

I Roadway	2½" Type A Base Surf.	205,215.9 Tons	132,782.9 cu.yds.
	1½" Type A Base Surf.	81,349.5 Tons	52,636.4 cu.yds.
	3/4" Type A Top Surf.	29,441.2 Tons	20,199.8 cu.yds.
	3/4" Type B Top Surf.	6,651.6 Tons	4,656.3 cu.yds.
	3/4" Plant Mix Agg.	37,672.5 Tons	25,106.6 cu.yds.
	Total I	360,330.7 Tons	235,382 cu.yds.
IG Roadway	2½" Type A Base Surf.	8,113.5 Tons	5,249.8 cu.yds.
	1½" Type A Base Surf.	3,065.6 Tons	1,983.6 cu.yds.
	3/4" Type A Top Surf.	1,172.0 Tons	804.1 cu.yds.
	3/4" Type B Top Surf.	454.4 Tons	318.1 cu.yds.
	3/4" Plant Mix Agg.	1,775.7 Tons	1,183.4 cu.yds.
	Total IG	14,581.2 Tons	9,539 cu.yds.

Original estimate amount in pit........332,181 cu.yds.
Total amount removed...................244,921 cu.yds.
Total amount remaining..................87,260 cu.yds.

REMARKS Only approximately 25% of the area of this pit was used to obtain this material.

Total Royalty Cost For This Project As Follows:
I Roadway - 235,382 cu.yds. x .05 per cu.yd. = $11,769.10
IG Roadway - 9,539 cu.yds. x .05 per cu.yd. = $ 476.95
Total For Project $12,246.05

Rev. 5-1-70

Figure II-9b

II-17 CONTRACT CHANGES

17.00 References

Standard Specifications: Articles 04.02, 04.03, 09.025, 09.03, 09.04, 09.05

17.01 General

Many conditions may be encountered that were not anticipated in planning or that cause changes in the original quantity estimate during the course of construction. The details of such changes must be reviewed by Project Manager and contractor so appropriate action can be taken to develop an adequate solution to the problem within the contract terms. In order that approval may be gained and authorization granted to perform necessary work involving various changes, procedures have been developed to categorize the types of changes and methods of resolvement.

17.02 Definitions

The following list defines various words and terms as they relate to contract changes.

1. Extra Work

   Extra Work is work outside the scope of the various contract items. Extra work is new and unforeseen and it is of such a nature that it cannot be covered by other contract items or combinations of contract items. Payment for extra work performed may be accomplished on a force account basis or by agreed prices. Authorization to perform extra work must be done in writing through an approved Extra Work Order.

2. Changed Condition

   These words refer to man's frequent inability to reasonably predict or accurately describe latent subsurface characteristics. A "changed condition" clause, if included in a contract, will appear in the contract special provisions and has been inserted therein for very specific reasons affecting that contract only.

3. Force Account

   The words "force account" describe a method of reimbursing a contractor for his actual expenses incurred for labor, equipment rental, materials and stated mark-ups involved in performing authorized extra work. Force account payments may fluctuate widely dependent upon the efficiency of the particular contractor involved. However, when prices to do the proposed extra work cannot be agreed upon, the work may be accounted for and paid on a force account basis.

4. Agreed Price

Payment for accomplishing extra work must have the contractor's and the engineer's mutual agreement, established and executed before any work may start. Guides for discussing and agreeing on a satisfactory price for use of equipment, labor and materials are: The current issue of equipment rental rates; established labor rates for that area and previous average bid prices or representative price quotations for material. Thereby, a price may be acceptable and agreed upon for establishing the basis for payment of extra work.

5. Unit Price

The price of one piece of a total volume of work is the unit price and is described in terms of dollars or fractions thereof per cubic yard, each mile yard, ton, acres, linear feet, etc. Unit prices establish the basis of payment for the numerous contract items encountered in highway construction. Unit prices are also used in change orders.

6. Contract Item

A specific unit or item of work described in detail by the contract. A pay item such as Unclassified Excavation, Prestressed Beam, Type "A" Top Surfacing, etc. Contract items are also used to describe work under a change order.

7. Eliminated Items

Contract items contained in the proposal may be found unnecessary for proper completion of the work. These unnecessary items may be eliminated without invalidating the contract providing a thorough review has occurred and approval has been obtained and executed by all parties to the contract. If an item is eliminated, the contractor may be reimbursed for actual work done and cost incurred excluding anticipated profits prior to his being notified of the elimination. Documentation for eliminating an item and payment of incurred costs is established by change order only.

8. Altered Quantities

The quantity of work as described in the contract under the various items of work when increased or decreased, have become "altered". Minor changes may usually be explained by final comparison notes whereas any substantial alteration or change in contract items require a change order or a supplemental agreement to document, explain and approve the change.

9. Supplemental Agreement

A supplemental agreement is a document executed by the Department of Highways and the contractor to amend the contract. It is used to authorize and establish the basis for payment for major increases or decreases in the contract quantities. A supplemental agreement may be used when any one of the following conditions exist:

(a) An increase or decrease of more than 25% in the length of the project.

(b) An increase or decrease of more than 25% of the total cost of the work as calculated from the original contract amounts.

(c) An increase or decrease of more than 25% in any major item.

(d) The quantity of extra work exceeds 25% of the original price of the total contract agreement.

10. Major Item

A major item has an original contract value exceeding 10% of the total original contract amount.

11. Minor Item

A minor item has an original contract value of less than 10% of the total original contract amount.

12. Change Order

A change order becomes an amendatory contract document after it is executed by the various Department of Highway engineers and the contractor. A change order may be used in place of a supplemental agreement when parties to the contract are mutually agreeable.

It documents contract changes in plans, specifications, eliminated items, quantities of major and minor items, changes in proposed equipment usage, specified materials and other allowed changes in the work as described in the contract. The basis of payment for a change order is the original unit price of the contract item or an agreed unit price.

13. Extra Work Order

An extra work order becomes a amendatory contract document after its execution by the various Department of Highways engineers and the contractor. It is used to document and establish the basis of payment for work not contemplated under the original contract.

14. Prior Approval

Written authorization must occur before any extra work, change ordered work or work under supplemental agreement may proceed. Verbal approval may be granted, for work of a very urgent nature where time is of the essence, but must be followed by written confirmation of such approval. The chain of command for obtaining prior approval for work on any project is Division Construction Supervisor, Construction Bureau and Federal Highway Administration engineers respectfully. The Construction Bureau will obtain prior approval from the Federal Highway Administration when needed.

17.03 Changed Conditions

The purpose of the changed condition clause is to minimize the contractor's risk of the unknown, and ultimately to reduce the cost of construction by reducing the necessary contingency allowances the contractor may apply to his bid in order to cover the cost of any unforeseeable changes. If it is determined that a changed condition did occur the contractor should be reimbursed only for his additional cost.

Changed condition problems are complex. They usually are the result of several features that were not anticipated by the designer nor planned for by the contractor. In some situations where the issues are complex, what appears to be a changed condition to the novice may be a perfectly normal situation that should have been foreseen and coped with routinely.

17.04 Supplemental Agreements

Supplemental agreements are used to establish an equitable basis of payment for extra work or changes in planned work that involves major increases or decreases. The facts, reasons, special problems and general events surrounding the apparent reasons for a supplemental agreement should be submitted to the Construction Bureau which will assure that consent of surety and additional surety bonds have been obtained (when required), data supporting costs are accurate and reasonable, results of all necessary studies are included, and that all parties to the agreement as well as those affected by it, are in agreement to the work as described. Prior approval for supplemental agreements is obtained only after execution by the parties to the contract.

17.05 Change Order, Extra Work Orders and Force Account Records

A. General

Change Orders and Extra Work Orders become legal documents after execution by the contractor and the engineer, and are as binding on each party as any provision of the original contract. For this reason these documents must be drawn with careful attention toward clarity, conciseness and accuracy, so that mutual agreement on methods and payment exists and the intention is obvious to the contractor and the engineer.

When contracts contain more than one project, any change orders or work orders must be handled and numbered as they pertain to the project involved rather than the overall work under the contract.

B. Documentation

Written proof, attested by dates and signatures, of existing conditions used to support the statement and prices in a change order or extra work order is called documentation. Documentation is always needed for any change order or extra work order and may consist of any one or a combination of the following depending on the nature of the change. The work order itself; daily force account records; contractors' letters of request; confirmation of "prior approval"; listing of various costs of labor, materials, equipment, etc.; invoices, bills of lading and letters to support agreed prices; test reports; certificates of guarantee; dated photographs and various letters or agreements used to authorize work or support payment for work under a change order or extra work order.

C. Prior Approval

The issuance of prior approvals for change orders is limited to those of an emergency nature. To be considered an emergency the work must be of such nature that the need could not have been reasonably anticipated.

Examples of situations which could be considered to be of an emergency nature are:

1. The contractor's completion of subsequent major work and completion of the project are dependent on prior approval.
2. Danger to the traveling public or adjacent residents and/or damage to any part of the project or adjacent property which might result due to a delay in accomplishing the work.

If the conclusion has been reached that an emergency does exist, then prior approval should be obtained as quickly as possible. Immediate approval may be gained by contacting the Construction Bureau via telephone, teletype or radio, relating the problem and giving an estimate of the quantity and cost of work involved. If it meets with his approval, someone from the Construction Bureau staff will contact the appropriate Federal Highway Administration Engineer. If approval is granted by telephone or radio, it will be followed by written confirmation. Whichever method is used, the completed change order or extra work order, with any necessary supporting documents, must be prepared and submitted as soon as possible. The date that prior approval was granted by the Construction Bureau should be shown.

To avoid turning routine change orders into emergencies, they should be prepared and processed as soon as it becomes evident the additional work is required. It is desirable to advise Federal Highway Administration Area Engineers of change orders being considered as soon as possible. However, do not delay the submittal of a change order awaiting the opportunity to discuss the matter with the Area Engineer if the delay will create an emergency situation.

If prior approval is granted, the contractor is to be given written authorization to proceed on the basis of payment discussed at the time prior approval was granted. See Article 04.03 Standard Specifications.

D. Change Orders

Various examples of contract changes authorized by typical change orders may be found in Figures II-10, II-10a, II-10b, II-10c, II-10d, and II-10e at the end of this section.

1. Authorization

(a) A change order authorizes and is required for changes such as increases or decreases in contract items, changes in Special Provisions, Supplemental Specifications, Standard Specifications and most plan changes. Minor routine plan changes do not require change orders. Examples of such minor changes include widening ditches, flattening slopes, small changes in lengths of pipe or guard rail, minor changes in location of pipe or guard rail, etc.

A change order is always required when the basis for payment is at an agreed price; when there is a question as to federal participation; and when additional contract time is to be allowed whether in accordance with 7th paragraph of Standard Specifications, Article 08.06, or by virtue of additional work performed which would not otherwise require a change order.

A change order is required when a contract item or related items vary from the contract amount by $5,000.00 or more. Examples of related items would be culvert excavation, bedding material and culverts or crushed base materials, crush top surfacing, water surface courses and rolling surface courses.

Overruns in bid items or groups of related bid items may occur before the need for a change order (based on $5,000.00 limit) is recognized. Payment for the overruns should not be withheld from progress estimates pending a better estimate of the total quantities.

Lesser overruns for which no change order is required should be paid for as they occur. These overruns should be explained with a note on the progress and final estimates.

(b) After a contract has been awarded, any change in the plans or specifications or both are generally discouraged unless the change meets one or more of the following criteria.

1. It is clearly impossible to construct in accordance with the plans or specifications.

2. It is clearly in the public interest to make the change because a superior product will be obtained at no extra cost.

3. It is in the public interest to make the change because the same product can be obtained at a substantial savings to the project.

Changes made for the contractor's convenience, at his request, usually result in a money savings to him and are generally discouraged unless the change satisfies one or more of the criteria cited above. If a change of this nature is found reasonable, the State should benefit from any money savings, before approval by change order, can be granted.

(c) Occasionally a contractor will do work or provide a product that does not meet all of the contract requirements but which can be accepted at a reduced price.

However, when honest attempts have been made to continuously meet the specification requirements, and documentation verifies these attempts, price adjustment may be made by change order but only after a thorough review has been made by field and headquarters personnel and the contractor has submitted a written request for a price adjustment.

2. Preparation

(a) Change orders are directives from the State to the contractor. When approved and accepted they become a requirement, that is to be followed. They are contract documents and as such must be specific. Do not use indefinite terms such as "it is proposed to" or "it is recommended that". Instead state that the work shall be done. Describe the work in a clear, concise manner so that a person unfamiliar with the project can understand the problem and the solution proposed. Attach a sketch if necessary.

Change orders are to be prepared, by the Project Manager in most cases, recommended by the Division Construction Supervisor and approved by the Construction Bureau. A space is provided for the signatures of these individuals, and the contractor's representative.

When the contractor's representative, usually the superintendent, signs a change order he is binding his company to the terms of the change order. Similarly, the State is bound to the terms of the change order by the signatures of its engineers.

(b) Occasionally the basis for performing work is in accordance with some Article of the Standard Specifications such as Article 07.15 (Act of God) or 04.04 (Maintenance directed by the engineer). If this is the case, the description should include a statement to that effect.

(c) The project number, change order number and other details of the heading must be completed accurately. Change orders are to be numbered in continuous sequence for each individual project under a contract even though a change order has been made void. Multi-project contracts must be administered to provide individual number groups for change orders involving each project.

(d) Additional contract time is to be allowed for additional and extra work before the projects are completed. Change order forms should show the additional time allowance. If no time is allowed, this should be shown as 0 days. The "money formula" should be used as a guide for determining the time extension. The number of days allowed when computed by the "money formula" shall be rounded to the nearest whole number.

$$\frac{\text{Dollars of Additional or Extra Work}}{\text{Dollar Value of Contract}} \text{ X Contract Days} = \text{Days Extension}$$

Sometimes extra or additional work needs to be accomplished which requires time not in proportion to the amount of dollars to be expended on the extra work. This should be brought out in the extra work order, stating why it will take additional time beyond that which would be allowed using the "money formula" and show the number of days required on this basis rather than by formula. Maybe the work will require more time to accomplish than allowed by the "money formula" but the contractor may be using only a fraction of his men and equipment on the extra or additional work. This must be taken into account too.

As an example, assume that by the "money formula" 7 days would be allowed. The contractor says it will take him 14 days to do the work. If only 50 percent of his work force and equipment and 50 percent of his earnings during that period are associated with the extra or additional work, 7 days would be a reasonable time allowance. The "money formula" does not normally result in a reasonable time extension when applied to calendar date projects and for this reason judgment must be used. An extension should be arrived at through discussion with the contractor.

Many change orders provide for items such as increases in traffic control, increase percentage of asphalt, additives for plant mix, etc. Items of this nature are not eligible for contract time extensions under the "money formula" because additional time is not required for the work to be done.

(e) Items occurring in one project may be used to describe necessary work for these same items that were not included in another project, under the same contract. This situation would be described as additional work and may or may not require a change depending on conditions described under Section 17.05 (D).

(f) A project that is divided into 2-lane and 4-lane I, IG, Rural and Municipal etc., may require additional work on one portion which has no item. For example, if an item is described in Rural but not included in Municipal and work in Municipal is necessary under that item, a change order may be used to authorize this additional work using the item and bid price described in the Rural Section. An overrun of an item or related items on the Rural Section and an underrun of the same item or same related items in the Municipal Section does not require a change order provided the net overrun or underrun is less than $5,000.00

(g) Evidence, occurring as a footnote in the lower right hand corner of the description frame, of a prior review by the Federal Highway Administration Engineer should appear on all change ordered work involving Federal participation. The footnote should state "Discussed with F.H.W.A. Engineer", be dated and show the engineer's name.

(h) All change orders shall be thoroughly checked in the field and Division Offices before submittal to Helena to assure that: Details on the heading, estimates and computations are complete and accurate; the additional contract time allowance is shown and is reasonable; the description is concise, intelligible and satisfies the work requirements; any necessary documentation is attached and is accurate; the contractor or his authorized representative and

Division Construction Supervisor have signed and dated the change order. The signatures will reproduce clear if a black ink is used for signing, typing should be dark and of good quality.

(i) Impending overruns in watering, rolling, culverts, bituminous materials and surfacing items should be estimated and a change order prepared well in advance of the completion of the items involved. Do not wait for the final estimate before sending a change order to cover these overruns.

(j) In some extraordinary instances, a contemplated overrun is impossible to determine until the item has been completed. In such cases, it is permissible to submit the change order when the item has been completed, provided that the problem has been previously discussed or approval granted by the Division Construction Supervisor, Construction Bureau, and the Federal Highway Administration Engineer. Written notice should be sent to the Construction Bureau stating the amount of overrun for inclusion in the project file. Examples of items that may fall in the above category are: Culvert extensions, deletions, substitutions, culvert excavation or backfill, adjustment to grade of manholes, valve boxes, etc., foundation piling, etc.

3. Agreed Unit Price

(a) An agreed price may be negotiated with the contractor when an item of work is required that is not adequately covered by a contract item, but can be properly covered if a contract item would have been provided.

(b) The previous years tabulation of average unit price bid for the various contract items, will be used as a guide to determine the propriety of an offered agreed unit price. Any substantial difference between the average unit price and the agreed price for work under one item will require complete justification and a thorough analysis or work, materials, equipment and the intended method of performance before approval can be issued.

(c) It is permissible to use the average unit price bid of the previous year for an agreed price item providing a reasonable average unit price bid was established. If only a small quantity of an item was used to establish the average price bid then it probably should not be used for the agreed price unless it can be determined that the price is reasonable.

(d) The agreed price should be supported by a detailed cost breakdown submitted by the contractor to justify and document his offered price. On small items it is not essential to have a detailed cost breakdown if the prices compare favorably with past average bid prices for those items or with prices on similar work on other projects nearby. A cost breakdown submitted should list the hours of labor and labor surcharges, equipment type and hours, materials (F.O.B. job site) handling charges and overhead. For detailed explanation of surcharges and cost breakdowns see Section 17.05 (E) 5-6-7. The cost estimate must be dated and signed by the contractor or his responsible representative. The use of the word "profit" is unacceptable in an agreed price cost detail. It is assumed that any profit derived from the work would have been included in the final agreed price although not stated as such in the detailed cost breakdown.

(e) The following statement must be shown on any change order containing agreed prices. "The agreed price and payment shall be full compensation for furnishing all material, labor, equipment, tools and incidentals necessary to complete the work".

4. Submittal

Send the original to the Construction Bureau after it has been documented, checked and signed by the contractor, and Division Construction Supervisor. Only one copy is needed of supporting documents. The Construction Bureau in Helena will make all necessary copies for distribution and retain the original in the permanent project file. A copy for reference may be made by the Division Offices for their files until an approved copy is returned.

5. Progress Payments

(a) Payment for work authorized by approved change order is to be made on the monthly progress estimate as the work is currently done.

(b) Payment for overruns of bid items under an approved change order are to be shown on the progress estimate by the words Change Order Number _________ placed in the line for description of the item.

(c) When agreed prices are involved, these shall be shown on the estimate below the regular listing of contract items and paid in the sequence appearing on the change order. Place the agreed price items under the heading "Work By Agreement", and mention the change order number on the line corresponding to the item involved. This will assist checking and processing.

E. Extra Work Orders

1. General

(a) Figure II-11, at the end of this section shows an example of a completed extra work order which may be used as a guide in preparing extra work orders for similar conditions. Should non-typical and unfamiliar circumstances arise, which are not adequately covered in this manual, contact the Construction Bureau for any aid felt necessary in preparation of the extra work order.

(b) A change order deals with additional work and authorized changes and substitutions in the planned contract work items. In contrast, an extra work order is the corresponding vehicle used to authorize any necessary extra work that was not described by the plans or contract provisions and for which a price cannot be agreed upon. The following comparative examples are presented to illustrate the difference between extra work and additional work.

> A 24" C.M.P., although not planned, is to be installed at Station 100 but no contract item exists for 24" C.M.P. This is classified as extra work but can most easily be handled by agreed prices, authorized by change order not an "extra work order".
>
> Work is necessary to provide an adequate approach and "turn around" by blasting rock near Station 20. No contract items exist that properly describes this type of work, and a price cannot be agreed upon. This is deemed as extra work to be authorized by an extra work order. Cost is documented by force account methods.

2. Authorization

(a) Authority to perform extra work may be granted through the signatures of the Division Construction Supervisor, Construction Bureau and Federal Highway Administration Engineers, after a thorough review of the unforeseen work situation.

(b) Any extra work performed, prior to or without an approved extra work order, is unauthorized work outside the scope of the contract, should not be accepted and will not be paid for by State or Federal monies. The State will not be held liable for any work performed prior to or without a written authorization. Never allow extra work to begin without prior approval by State and Federal Highway Administration Engineers.

(c) The use of an extra work order (Form Number 12) as an agreement to perform railroad or utility work will not be honored nor permitted. Form Number 12 provides for a surcharge on both labor and material costs which is not applicable to railroad or utility work.

3. Supporting Documents

(a) Materials incorporated in the extra work must be substantiated by a legible copy of each invoice. The invoices for materials used are to accompany the extra work order when it is submitted with the final data.

(b) A letter from the contractor stating and certifying his surcharge rates for labor, health and welfare, the premium on bond, etc., is to be obtained before payment is allowed for the work. This letter is to accompany the final estimate as supporting data. The contractor's payroll is to be used in verifying the correct rate to use for workmen.

(c) The daily record of force account work performed is the prime ingredient supporting payment for extra work. This record, Form CSN 12, must be signed by the contractor or his representative and engineer or inspector on a daily basis to be a valid chronological record. Labor is to be listed on CSN Form 12 by name and classification.

4. Preparation

(a) All extra work orders are to be submitted with a clear, concise and accurate description of the intended work. The extra work order should describe the work in sufficient detail to enable an engineer who is personally unfamiliar with the project to gain an intimate understanding of the situation, the reasons for it and the suggested remedial action.

(b) The project number, extra work order number and other details in the heading must be accurately completed. Extra work orders are to be numbered in continuous sequence for each project under a contract even though an extra work order has been made void. Multi-project contracts must be administered to provide individual number groups for each project.

(c) The prices in extra work orders are to be broken down to correspond with any Project Agreement estimate breakdown such as 2-lane, 4-lane, rural, municipal, I, IG, when work involves these project splits.

(d) Evidence of a prior review by the Federal Highway Administration Engineer should appear as a footnote placed in the lower right hand corner of the description frame, when the extra work involves federal participation. The footnote should state, "Discussed with Federal Highway Administration Engineer," be dated and show the Engineer's name.

(e) All extra work orders must be thoroughly checked in the field and Division Offices before submittal to Helena, to assure that: Details in the heading, estimates and computations are complete and accurate; the description is concise, intelligible and satisfies the work requirements; any necessary documentation is attached and is accurate; the contractor or his authorized representative has signed and dated each copy of the extra work order and that the Division Construction Supervisor has also signed and dated each copy.

5. Surcharges, Premiums and Insurance Costs

(a) The contractor actually performing the work is to submit a letter with a signed statement that he certifies to the various labor, health and welfare and other surcharges, premiums on bonds, liability insurance costs, industrial accident insurance costs.

Unemployment Compensation and Social Security rates. The letter should list the rates paid by the company doing the work, and be attached to the extra work order when it is submitted for approval. Subsequent change orders or extra work orders for the same project and contractor do not require a breakdown of surcharges.

(b) Labor Surcharges may be as high as 20% and are figured on total labor costs to include all wages, insurance, and Health, Welfare and Pension Costs, and do include the time for a contractor's superintendent.

(c) Industrial Accident Insurance Surcharges are variable depending on the type of work involved. Compute overtime rate from the rate for straight time. The surcharge rates for straight time may vary from 3.90% to 21.65% or more depending upon the type of work. The rates can be verified through the Workmen's Compensation Division. A contractor may have insurance with a private company. The rates may differ from those established by the Workmen's Compensation Division, but are acceptable if properly substantiated.

(d) Public Liability and Property Damage Insurance is a permissible surcharge that is variable. Rates depend upon a particular contractor's record and accident history.

(e) Unemployment Compensation Surcharges are somewhat variable but should rarely exceed 2.9% of the gross wage. Employers with 10 or more years of experience may receive a reduction in this rate. The federal rate is 0.58% for a total allowable charge of 3.48%. For rate claims over 3.48% contact the Construction Bureau for clarification.

(f) Social Security Surcharges are allowable for the current rate in effect but the contractor may claim only what he contributes not what the employee also contributes. The Social Security rate effective January 1, 1973 is 5.85%.

(g) The Premium on Bond is generally 1% or less as figured on the total estimated cost of extra work, including the premium itself.

Example: Using Costs from Fig. III-11
Premium on Bond = 0.91% of Total Estimated Cost.

Total Estimated Cost =
Total Labor, Equipment, Materials + Premium on Bond

Total Estimated Cost =
1,968.80 + 0.00091 Total Estimated Cost

$$\text{Total Estimated Cost} - 0.0091\ \text{Total Estimated Cost} = 1,968.80$$

$$0.9909\ \text{Total Estimated Cost} = 1,968.80$$

$$\text{Total Estimated Cost} = \frac{1,968.80}{0.9909}$$

$$\text{Total Estimated Cost} = 1,986.88$$

Premium on Bond can be found by subtracting Total Labor, Equipment, and Materials from Total Estimated cost or by taking 0.91% of Total Estimated Cost.

$$\begin{array}{r} 1,986.88 \\ -\underline{1,968.80} \\ 18.08 \end{array} \quad \text{or} \quad 1,986.88 \times 0.0091 = 18.08$$

Both methods will give the same result. If they don't, something is wrong.

6. Equipment, Methods and Workmen

(a) The contractor may choose the type of equipment to use in performing the various parts of the work presuming that his choice will result in a reasonably efficient procedure. The engineer can and should request a change in equipment, methods or workmen when those used do not result in a reasonably efficient progress.

For instance, assume that force account is used to make guardrail adjustments and that laborers are chosen by the contractor to dig the numerous holes in good earth rather than using an augering machine. This is clearly an inefficient work procedure which if allowed will be more costly than the use of an auger, so in order to speed the work, the engineer should request the use of an auger.

Judgment must be exercised in determining what procedure is efficient and what is not, so that no big fuss is made over borderline situations (where one work method or piece of equipment is just as good as another). However, poor practices must be corrected.

When a dispute arises as to the work method or piece of equipment to be used, the engineer has authority to change the procedure or allow the contractor his way. Force account work is truly under the engineer's direction so if the contractor wants to use a work method or piece of equipment that is obviously unsatisfactory he is to change to a more efficient or better system.

(b) Frequently, force account work will occur in constricted areas, over rugged terrain, in very difficult material or in hazardous areas. Contractors want more payment for difficult work and will try to gain the sympathetic ear of the engineer who, if he has not read the specifications dealing with force account work and the instructions in the equipment rental rate booklet, may be induced to pay a bit more for the work than is fair and reasonable.

For instance, if a piece of equipment breaks down (breakdowns may be more numerous when in difficult material), the mechanic may be used to fix it or it may be set aside unused. No payment can be allowed for the time the equipment was idle and similarly no reimbursement can be allowed for the parts or labor required for repair, since neither of these happenings contribute to the productive effort, instead they are expected events. Repair in itself neither adds or takes away from production but only allows production to continue.

The rental rates for equipment used in performing force account work have included therein, a reasonable allowance for down time and repair expenses, for the cost of fuel, lubricants, maintenance and certain amount of profit. A mechanic's wages should never be allowed for repair.

(c) A foreman's time may be added provided that he actually takes part in the work and the time he works is accounted for. If the contractor is actually paying Health, Welfare and Pension charges on the foreman these are allowable surcharges.

(d) When equipment standby is required only fifty (50) percent of the total hourly rental rate will be applicable.

(e) Payment for "Move In and Move Out" charges on equipment not available on the project are handled as follows:

1. When equipment is not moved under its own power the payment is based on actual transportation costs.

2. When equipment is moved under its own power, seventy (70) percent of the total hourly rental rate, without operator, is allowed.

7. Submittal

Change orders and extra work orders become legal documents after execution by the contractor and the engineer, and are as binding on each party as any provision of the original contract. For this reason these documents must be drawn with careful attention toward clarity, conciseness and accuracy, so that mutual agreement on methods and payment exists and the intention is obvious to the contractor and engineer.

When contracts contain more than one project, any change orders or work orders must be handled and numbered as they pertain to the project involved rather than the overall work under the contract.

When submitting the final estimate, supporting data is to include the daily force account notes (CSN Form 12). This form has appropriate spaces for accumulative totals of labor, materials and equipment actually used in the extra work and include all additives, surcharges, fringes, etc.

8. Progress Payments

(a) Payment is to be made, for extra work, on the monthly progress estimates as the work is currently done during that estimate period. The practice of estimating work done near the end of the monthly pay period is discouraged. The force account form CSN 12 provides for exact determination of work accomplished and is the only method of substantiating payment for force account work. Estimating the probable amount of work to be done could lead to unsubstantiated overpayments.

Payment is not to be made, nor is extra work to be done until an approved extra work order is received by the Project Manager. Exceptions are permitted when prior approval is granted.

(b) It is permissible to overrun the original extra work cost estimate without substantiating the overrun by a supplemental extra work order providing the overrun does not exceed the original value of the extra work as shown in the following table. When an overrun exceeds the amounts or percentages in this table, a supplemental extra work order must be submitted to authorize the overrun.

Amount of Original Extra Work Order	Allowable Overrun
$ 0 to $ 1,000	$ 75%
$ 1,001 to $ 5,000	$ 500 + 25%
$ 5,001 to $10,000	$ 750 + 20%
$10,001 and up	$1,750 + 10%

F. Force Account Records

1. All extra work must be performed under authorization of an approved extra work order or supplement, thereto, and any payments shall be made on a force account basis. The force account basis consists of a daily tabulation, on CSN Form 12, of all labor, equipment and materials used in the work. The daily work must be attested to, by the signatures of the contractor's representative and inspecting engineer, at the end of each shift worked. These force account records will constitute the true record of any extra work performed. Labor is to be listed on CSN Form 12 by name and classification.

2. The various acceptable surcharges have been previously shown under Section II-17.05(E) (5) of this manual and will be the major guidelines for surcharge allowances. Surcharge allowances are to be for the actual amount the contractor is paying and should be substantiated, in writing by the contractor. The direct costs allowed for labor, materials and equipment must conform to the statement in Article 09.04 of the Standard Specifications which has been condensed below:

(a) Payment for labor, and foreman in charge of work will be guided by the labor rates stated in the contractor's payrolls plus 20% surcharge.

(b) The contractor will receive payment for the actual delivered cost, as shown by bills and invoices, of all materials used plus 15%.

(c) The equipment rental rates, which include fuel and lubricants, repairs, mechanic's wages and related equipment to be used will conform to the current issue of the "Equipmental Rental Rates"; a Montana Department of Highways publication. Any rental rates not shown may have a reasonable price established by mutual agreement between the Project Manager and contractor after consultation with Construction Bureau personnel.

(d) The actual costs imposed on the contractor by the State or Federal law for various insurances and premium on the performance bond are reimbursable. The actual cost of these expenses will be increased by 20%. The 1% gross receipts license fee is not recognized as reimbursable.

(e) Payment received on a force account basis will constitute payment in full for the work performed and will include superintendents and the use of tools or other incidentals for which no rental or profit is allowed.

G. Freight Rate Increases

1. In Article 09.025 of the Standard Specifications certain materials are designated as eligible for a common carrier rate adjustment. Under the provisions of this specification the contractor may be reimbursed for the actual increased cost of freight incurred by an increase in the common carrier rate between the time of the letting of the contract and the date of delivery of the materials. A properly prepared change order for a freight rate adjustment will contain the following items:

(a) Freight rates in effect at the time of the letting of the contract and rates in effect at the time of delivery. If part of the materials were delivered under one rate and the rest under another be sure to separate the quantities for proper computation of the adjustment.

(b) Verification that materials were shipped from nearest available source. If the materials were available at a source nearer than the one used, the freight increase will be calculated from the nearest source regardless of the point from which the materials were shipped.

(c) The freight paid on the materials shipped may be shown separately from the unit price for the materials. Substantiation in the form of invoices or certified statements from the common carrier showing freight as would normally be shown on a bill of lading will be necessary. Materials hauled by a contractor who is not a licensed common carrier are not eligible for a freight rate adjustment.

(d) For materials shipped F.O.B. construction site attach the purchase agreement which must have a clause in it whereby the purchaser and supplier agree that the price quoted is subject to adjustment if the freight rate changes. If no purchase agreement exists, an affidavit stating such and including the clause about freight rate adjustment of purchase price should be attached to the change order. As in (c) the invoice or a certified statement showing increases due to freight adjustment must also be attached.

2. Substantiation of the change order must be reviewed carefully to insure that each of the above items are complied with. A properly prepared change order and some sample attachments are shown in Figure II-12a, b, and c.

Form 13 Rev. 3-71 10M 3

STATE OF MONTANA
DEPARTMENT OF HIGHWAYS

CHANGE ORDER

Change Order No. 1
Project Number
F-RF 250 (28) U-1

To BORROW CONSTRUCTION COMPANY
Contractor

March 28 1973
Date

You are hereby directed to perform the following work, constituting changes in the approved contract. The State Highway Commission will not be liable for any work, not provided for in the contract, performed prior to the approval thereof.

WORK DESCRIPTION

The Plans provide 156 lineal feet of 36" culvert at station 881+09.1, to replace a double 60" culvert installation.

In order to adequately fulfill area drainage requirements:

1) Change the planned 36" x 156' CSP Culvert at Station 881+09.1 to 60" x 264' CSP Culvert.

2) Change the skew alignment from planned 29 degrees 57 minutes to 49 degrees 27 minutes to provide for a satisfactory inlet and outlet.

The agreed price and payment shall be full compensation for furnishing all labor, tools, equipment, materials and incidentals necessary to complete the work.

One additional day will be allowed to complete the work using the money formula to compute the additional time.

Discussed with J. T. Owens, FHWA Area Engineer, March 20, 1973
Reviewed and recommended by the Hydraulics Engineer, Dept. of Highways, March 8, 1973

ESTIMATE AND COST

Note: The quantities shown are not guaranteed to be used and are subject to change on the final estimate.

Item	Quantity	Unit	Description	Unit Price	Amount
TYPE CODE	6201				
			2-LANE RURAL INCREASE (AT AGREED PRICE)		
	264	Lin.Ft.	60" CSP Culvert .064 Type A Bit.	$39.59	$10,451.76
			2-LANE RURAL INCREASE (AT UNIT BID PRICE)		
521005000	600	Cu.Yd.	Excavation Culvert	$ 5.00	$ 3,000.00
			DECREASE (AT UNIT BID PRICE)		
561036061	156	Lin.Ft.	36" CSP Culvert .064 Type A Bit.	$20.00	$ 3,120.00

Time extension 1 days

Total cost (increase) ~~(decrease)~~ $10,387.20

I hereby understand and agree to the terms and conditions set forth in this instrument.

BORROW CONSTRUCTION CO.
Contractor or Firm

By

Title

APPROVED

Mgr. Field Project Unit Date

Sup. Div. Const. Section Date

Const. Bureau Date

Project No. F-RF 250 (28) C.O. No. 1

Transmitted to FHWA —

Approved by FHWA —

Fig. II-10

Rev. 5-1-73

Borrow Construction Company
P.O. Box 120
Lewistown, Montana 59457

March 27, 1973

John T. Doe, Mgr. F.P.U.
Montana Department of Highways
Box 80
Lewistown, Montana 59457

Re: Project No. F-RF 250(28) Unit 1

Dear Mr. Doe:

Our prices, which you have requested for the drain culvert at Station 881+10, are as follows:

EQUIPMENT

Patrol (Cat #14)	27.10	16 hrs.	$ 433.60	
Loader (2 Yd.) Whl. Ty.	18.80	14 hrs.	$ 263.20	
Scraper (Twin Eng.) 21 C.Y.	58.80	4 hrs.	$ 235.20	
Compactor (WC-17) 25 T	36.55	5 hrs.	$ 182.75	
DW21 Water Tanker 8000 Gal.	29.00	5 hrs.	$ 145.00	
Pickup (3/4 Ton)	2.75	18 hrs.	$ 49.50	
D8 -36-A & Disc (36" x 12')	42.90	5 hrs.	$ 214.50	
*Compressor (125 CFM) Gas	8.30	16 hrs.	$ 132.80	
Wacker (Over 36#)	2.00	16 hrs.	$ 32.00	
*With single unit backfill tamper			$1,688.55	$ 1,688.55

LABOR

Laborers	5.05	32 hrs.	$ 161.60
Foreman	7.20	18 hrs.	$ 129.60
Teamster	6.10	5 hrs.	$ 30.50
Operator - Scraper	7.10	4 hrs.	$ 28.40
Operator - Patrol	7.00	16 hrs.	$ 112.00
Operator - Loader & Compactor	6.87	24 hrs.	$ 164.88
			$ 626.98

PAYROLL EXPENSES

FICA	5.85	
Unemployment	3.40	
Workmen's Comp.	3.90	
PL & PD	3.00	
	16.15%	$ 101.26

Fig. II-10a

FRINGE BENEFITS

Travel	6.00	14 days	$ 84.00	
Operators	.92	62 hrs.	$ 57.04	
Laborers	.63	32 hrs.	$ 20.16	
Teamsters	.75	5 hrs.	$ 3.75	
			$ 164.95	
20% Labor Costs			$ 178.64	$ 1,071.83
		TOTAL		$ 2,760.38

MATERIALS

264 Lin. Ft. 60 in. .064' 3" x 1" Bit. Coated CSP.	23.89		$ 6,306.96	
10 Bands	33.59		$ 335.90	
			$ 6,642.86	
15% Materials Cost			$ 996.43	
			7,639.29	
LABOR & EQUIPMENT COSTS			$ 2,760.38	
			$10,399.67	
.5% Bond			$ 52.26	
		TOTAL		$10,451.93

Total Cost per Foot = $39.59

Very truly yours,

BORROW CONSTRUCTION CO.

ABC:zz

Fig. II-10b

Rev. 5-1-73

Form 13 Rev. 3-71 10M 3

STATE OF MONTANA
DEPARTMENT OF HIGHWAYS

CHANGE ORDER

Change Order No. 1
Project Number
I 15-5 (32) 67 U-1

To JONES CONSTRUCTION COMPANY
Contractor

April 20 19 73
Date

You are hereby directed to perform the following work, constituting changes in the approved contract. The State Highway Commission will not be liable for any work, not provided for in the contract, performed prior to the approval thereof.

WORK DESCRIPTION

Type Code 6201
4-Lane Rural

Center lines of Main Line and P.T.W. are located so far apart, between stations 1380+00 and 1580+00, that planned slopes intersect from six to eighteen feet below finished grade. Correcting this to enhance the aesthetic quality of the project creates no special problem except in the areas where culverts under the Main Line are or must be connected to existing culverts under the P.T.W. to provide drainage continuity.

To accomplish this, lengthen the riser pipes at stations 1409+47, 1460+50, 1469+06, 1547+77; install a Tee section, concrete collars and Median Inlet Covers Type I for the 48" culvert at station 1447+84; install Median Inlet Covers Type I at stations 1409+47, 1547+77 and make a 0.7' elevation correction for the culverts at station 1547+77 with concrete collars.

Raising the ditch grade and flattening the slopes will provide a greater safety factor. Therefore, eliminate the need for Guard Rail, Embankment Protector, Bank Protecting Type 3 and Bituminous Curb planned on the left from station 1447+55 to station 1453+17.5.

Discussed with FHWA Area Engineer, H.S. Adams, April 2, 1973

ESTIMATE AND COST

Note: The quantities shown are not guaranteed to be used and are subject to change on the final estimate.

Item	Quantity	Unit	Description	Unit Price	Amount
Type Code 6201 4-Lane Rural			INCREASE CONTRACT ITEMS		
111010000	5,570	Cu.Yd.	Excavation Unclassified	0.39	2,172.30
621024020	70	Ln.Ft.	RCP Culvert 24" Cl. 2	9.50	665.00
621048050	10	Ln.Ft.	RCP Culvert 48" Cl. 5	40.00	400.00
401030000	4.0	Cu.Yd.	Concrete - Class DD	350.00	1,400.00
774000241	3	Each	Inlet Cover 24" Type 1	350.00	1,050.00
			Sub-Total		5,687.30
			DECREASE CONTRACT ITEMS		
503003000	1.5	Cu.Yd.	Bank Protection Type 3	13.00	19.50
567012000	50	Ln.Ft.	Embankment Protector 12"	7.00	350.00
751200010	562.5	Ln.Ft.	Curb - Bituminous	1.10	618.75
901106256	562.5	Ln.Ft.	Guard Rail - Steel/Conc. Posts	6.00	3,375.00
			Sub-Total		4,363.25

Time extension 0 days

Total cost (increase) ~~(decrease)~~ 1,324.05

I hereby understand and agree to the terms and conditions set forth in this instrument.

JONES CONSTRUCTION CO.
Contractor or Firm

By Tom Jones Jr.

Title President

APPROVED

Mgr. Field Project Unit Date

Sup. Div. Const. Section Date

Const. Bureau Date

Project No. I 15-5 (32) 67 U-1 C.O. No.

Transmitted to FHWA —

Approved by FHWA —

Fig. II-10c

Rev. 5-1-73

Form 13 Rev. 3-71 10M 3

STATE OF MONTANA
DEPARTMENT OF HIGHWAYS

CHANGE ORDER

Change Order No. 3
Project Number
F 100 (5)

To JONES CONSTRUCTION COMPANY
Contractor

May 2 1973
Date

You are hereby directed to perform the following work, constituting changes in the approved contract. The State Highway Commission will not be liable for any work, not provided for in the contract, performed prior to the approval thereof.

WORK DESCRIPTION

In order to properly direct and protect the traveling public, it is necessary to use additional flagging hours, pilot cars and signs over and above the amount provided. On the basis of construction to date, it is necessary to increase the contract quantity for traffic control by 3,500.00 units.

ESTIMATE AND COST

Note: The quantities shown are not guaranteed to be used and are subject to change on the final estimate.

Item	Quantity	Unit	Description	Unit Price	Amount
			INCREASE CONTRACT ITEMS		
			2 - Lane Rural		
165000000	3,500.00	per unit	Traffic Control	1.00	3,500.00

Time extension 0 days

Total cost (increase) ~~(decrease)~~ 3,500.00

I hereby understand and agree to the terms and conditions set forth in this instrument.

JONES CONSTRUCTION COMPANY
Contractor or Firm

By Tom Jones Jr.

Title President

APPROVED

Mgr. Field Project Unit Date

Sup. Div. Const. Section Date

Const. Bureau Date

Project No. F 100 (5) C.O. No. 3

Transmitted to FHWA — 2-20-67

Approved by FHWA —

Fig. II-10d

Rev. 5-1-73

Form 13 Rev. 3-71 10M 3

STATE OF MONTANA
DEPARTMENT OF HIGHWAYS

CHANGE ORDER

Change Order No. 1
Project Number F 100 (5)

To JONES CONSTRUCTION COMPANY (Contractor)
June 11 19 73 (Date)

You are hereby directed to perform the following work, constituting changes in the approved contract. The State Highway Commission will not be liable for any work, not provided for in the contract, performed prior to the approval thereof.

WORK DESCRIPTION

Special Provision No. 6 states that, "Placer Dredge Tailing Dumps will not be an acceptable source for surfacing material". However, with the proper handling, acceptable surfacing material can be produced from these dumps.

Therefore, Special Provision No. 6 is changed to allow tailing dumps to be used as material sources, provided the material produced passes the specifications set up for that particular material.

Discussed with FHWA, Area Engineer - H. S. Adams

ESTIMATE AND COST

Note: The quantities shown are not guaranteed to be used and are subject to change on the final estimate.

Item	Quantity	Unit	Description	Unit Price	Amount
			Change Special Provision No. 6 to allow the use of tailing dumps as material source.		

Time extension 0 days

Total cost (increase) (decrease) 00.00

I hereby understand and agree to the terms and conditions set forth in this instrument.

JONES CONSTRUCTION CO.
Contractor or Firm
By Tom Jones Jr.
Title President

APPROVED

Mgr. Field Project Unit Date
Sup. Div. Const. Section Date
Const. Bureau Date

Project No. F 100 (5) C.O. No. 1

Transmitted to FHWA — 6-12-73
Approved by FHWA —

Fig. II-10e

Rev. 5-1-73

FORM 12, REV. 11-61--5M 12-65 82816 REPORTER 3

STATE HIGHWAY COMMISSION
HELENA, MONTANA

PROJECT NUMBER	E. W. ORDER
F 100(5)	No. 1

"Extra Work" and "Extra Material" Order
(FORCE ACCOUNT BASIS)

TO CONTRACTOR Jones Construction Company

ADDRESS P.O. Box 500 Butte, Montana 59701

In accordance with the provisions of the Standard Specifications, amendments and Special Provisions governing your contract dated June 20, 19 72, you are hereby authorized to perform or furnish "Extra Work" or "Extra Material" on Federal Aid Project No. F 100(5) in Wibaux County, Montana. In making claim for this work or material reference must be made to the above project and extra work number.

The amount to become due the contractor will be determined by the Engineer as provided by the Standard Specifications. The State Highway Commission will not be liable for the payment for any Extra Work or Extra Material performed or furnished prior to the approval of this order.

DESCRIPTION OF WORK AND SPECIFIC INSTRUCTIONS TO CONTRACTOR

Install 310 L.F. of 6 inch steel casing at Station 100+50.0

This installation is required as part of the R/W agreement with the landowner and was not shown on the plans.

CONTRACT EXTENTION TIME: 1 day

Discussed with Federal Highway Administration Area Engineer-H.S. Adams August 30, 1970.

NOTE: Do not use back of this form, Form CSN 12 is to be used. Use extra sheet if there is not enough room on this form for breakdowns.

Estimated cost	ITEMS					AMOUNT	
Material	6" Black Steel Pipe, 15-21' lengths, 315 L.F. @ 3.00/L.F. = $945.00 10 lbs. welding rod @ 0.28/lb. 2.80						
					Total Material Cost	947.80	(1)
					15% of Material Costs	142.17	(2)
Labor Classification		Hours	Rate				
Motor Grader Operator	3-71	2	7.00	14.00			
Loader Operator	3-94	8	6.87	54.96			
Welder	3-66	4	6.97	27.88			
Labor - Pipe Layers	1-35	32	5.20	166.40			
Foreman		8	7.00	56.00			
Health, Welfare, Pension				319.24			
Operator, Welder, Foreman		22	.92	20.24			
Labor		32	.63	20.16 40.40	Total Labor Cost	319.24	(3)
~~15% on Labor~~; 3.5 % Ind. Acc. Ins.; 5.2 % Soc. Sec.; 4.3 % P. L. & P. D.; 3.2 % Unemp.					(16.2)	51.72	(4)
Equipment	Type	Hours	Rate				
Pickup	6000 GVW	4	2.75	11.00	H.W. & Pension	40.40	
Patrol	#14 cat	2	27.10	54.20	20% on Labor	82.27	
Loader	3 CY Rubber	8	24.40	195.20			
Welder	300 AMP Gas	4	5.30	21.20			
Air Comp (gas)	175CFM & 2 single Tampers	8	12.95	103.60	Total Equipment Cost	385.20	(5)
Premium on Bond, 0.91% of Total Est. Cost.						18.08	(6)
Total Estimated Cost ~~(Add 1, 2, 3, 4, 5, 6)~~						1,986.88	

Issued January 5, 19 73 By John T. Doe Resident Engineer. Inspector.

Accepted January 5, 19 73

Jones Construction Company
Contractor or Constructing Firm

By

Title

Recommended

Date, 19
Div. Engr.

Date, 19
Dist. Engr.

Approved

By Date, 19
Const. Engr.

FIG. II-11

Rev. 5-1-73

FEDERAL AID PROJECT NO.

Detail of Work Order No.............................. **Final Items**

Force, Material or Equipment Rentals

Year............ Month	Day	DESCRIPTION	No. of Hours Days	Rate Hours Days	AMOUNT
		TOTAL DUE THIS ORDER			

I hereby certify that the details and total amount of this order are correct.

....
Division Engineer.

Rev. 5-1-73

STATEMENT OF DAILY FORCE ACCOUNT WORK

Project No. F 100 (5)

E.W.O. No. 1

Page No. 1

Date April 23, 1973

Description of Work Installation of 6 inch Steel Casing at Station 100+50.0

(Labor) Name		Classification	Hours	Rate	Extended Amt.
Frank T. Johnson	3-94	Loader Opr.	4	6.87	27.48
Percy E. Thomas	3-66	Welder	2	6.97	13.94
Stanley W. Wilson	1-35	Labor-Pipelayer	8	5.20	41.60
John E. Murphy	1-35	Labor-Pipelayer	8	5.20	41.60
Raplh B. Hinkle		Foreman	2	7.00	14.00

Wage Rates Verified Against:

#10 4-16 to 4-20 1973

Verified By:

Total Payroll	138.62
Labor Surcharge @ 16.2 %	22.46
Others Health, Welfare &	
Pension operator, welder &	
foreman-8 hrs. @ 0.92	7.36
Labor - 16 hrs. @ 0.63	10.08
Sub Total	178.52
+ 20 % On Labor Costs	35.70
Page Total Cost Of Labor	(A)214.22
Total Labor Cost Br't. Fw'd.	
Total to Date Cost of Labor	(A)214.22

CSN 12

Fig. II-11a

Rev. 5-1-73

Materials	Unit	Quantity	Unit Price	Amount
6 Inch Black Steel Pipe	LF	126	3.00	378.00
Welding Rod	LB	5	0.28	1.40

Sub Total		379.40
+ 15% on Material Costs		56.91
Page Total Cost of Mat'l.	(B)	436.31
Total Mat'l. Br't. Fw'd.		
Total to Date for Material	(B)	436.31

(Equipment)	Description	Hours	Rate	Extended Amt.
Pickup	6000 GVW	2	2.75	5.50
Loader	3 C.Y. Rubber	4	24.40	97.60
Welder	300 AMP Gas	2	5.30	10.60
Air Comp	(gas) 175 CFM & 2 Single Tampers	4	12.95	51.80

Rental Rates Obtained From:
Montana Department of Highways
Rental Rates 1973

Sub Total		165.50
Page Total Cost Of Equip.	(C)	165.50
Equip. Cost Br't. Fw'd.		
Total to Date for Equip.	(C)	165.50
Total to Date (A) (B) (C)		816.03
+ Premium on Bond		
Total Force Acc. to Date		

Approved:

Contractors Representative Title

State Representative Title

Fig. II-11b

Project No. F 100 (5)

E.W.O. No. 1

STATEMENT OF DAILY FORCE ACCOUNT WORK

Page No. 2

Date April 24, 1973

Description of Work Installation of 6 Inch Steel Casing at Station 100+50.0

(Labor) Name		Classification	Hours	Rate	Extended Amt.
Lloyd F. Nolan	3-71	Motor Grad.Opr.	3	7.00	21.00
Frank T. Johnson	3-94	Loader Opr.	3	6.87	20.61
Percy E. Thomas	3-66	Welder	1	6.97	6.97
Stanley W. Wilson	1-35	Labor-Pipelayer	8	5.20	41.60
John E. Murphy	1-35	Labor-Pipelayer	7	5.20	36.40
Ralph B. Hinkle			6	7.00	42.00

Wage Rates Verified Against:

Prime Contractor Payroll

#10 4-16 4-20 1973

Verified By:

Total Payroll		168.58
Labor Surcharge @ 16.2 %		27.31
Others		
Health Welfare & Pension		
operator, welder, foreman		
13 hrs. @ 0.92		11.96
Labor-15 hrs. @ 0.63		9.45
Sub Total		217.30
+ 20 % On Labor Costs		43.46
Page Total Cost Of Labor	(A)	260.76
Total Labor Cost Br't. Fw'd.		214.22
Total to Date Cost of Labor	(A)	474.98

CSN 12

Fig. II-11c

Rev. 5-1-73

Materials	Unit	Quantity	Unit Price	Amount
6 Inch Black Steel Pipe	LF	189	3.00	567.00
Welding Rod	LB	7	0.28	1.96

Sub Total		568.96
+ 15% on Material Costs		85.34
Page Total Cost of Mat'l.	(B)	654.30
Total Mat'l. Br't. Fw'd.		436.31
Total to Date for Material	(B)	1,090.61

(Equipment)	Description	Hours	Rate	Extended Amt.
Patrol	#14	3	27.10	81.30
Pickup	6000 GVW	6	2.75	16.50
Loader	3 C.Y. Rubber	3	24.40	73.20
Welder	300 AMP	1	5.30	5.30
Air Comp (gas)	125 CFM & 2 Single Tampers	8	12.95	103.60

Rental Rates Obtained From:
Montana Department of Highways
Rental Rates - 1973

Sub Total		279.90
Page Total Cost Of Equip.	(C)	279.90
Equip. Cost Br't. Fw'd.		165.50
Total to Date for Equip.	(C)	445.40
Total to Date (A) (B) (C)		2,010.99
+.91 Premium on Bond		18.47
Total Force Acc. to Date		2,029.46

Approved:

Contractors Representative Title

State Representative Title

Fig. II-11d

Rev. 5-1-73

Form 13 Rev. 3-71 10M 3

STATE OF MONTANA
DEPARTMENT OF HIGHWAYS

CHANGE ORDER

Change Order No. 6
Project Number
I 90-2(32)67 U-1

To JONES CONSTRUCTION COMPANY
Contractor

May 10 1973
Date

You are hereby directed to perform the following work, constituting changes in the approved contract. The State Highway Commission will not be liable for any work, not provided for in the contract, performed prior to the approval thereof.

WORK DESCRIPTION

The Interstate Commerce Commission granted $0.01 per cwt. increases on two occasions after this project was let to contract and before delivery of the materials listed below. These increases are represented by Tariff_______ effective June 4, 1971 and Tariff_______ effective February 16, 1972.

In accordance with Article 09.025 of the Supplemental Specifications you are hereby being allowed a $0.02 per cwt. freight rate adjustment for the cement incorporated into the Cement Stabilized Base, 7" & 8" P.C.C. Paving and Bridge Approach Slabs.

Copies of the Burlington-Northern, Inc. freight bills are being retained in the project files.

> "The agreed price and payment shall be full compensation for furnishing all materials, labor, equipment rental, tools and incidentals necessary to complete the work."

SEE ATTACHED SHEETS

ESTIMATE AND COST

Note: The quantities shown are not guaranteed to be used and are subject to change on the final estimate.

Item	Quantity	Unit	Description	Unit Price	Amount
4-LANE RURAL Type Code 6201			INCREASE AGREED PRICE		
	400,114	CWT	Freight Rate Adjustment	$0.02	$8,002.28

Time extension 0 days

Total cost (increase) (decrease) $8,002.28

I hereby understand and agree to the terms and conditions set forth in this instrument.

JONES CONSTRUCTION CO.
Contractor or Firm

By

Title

APPROVED

Mgr. Field Project Unit Date

Sup. Div. Const. Section Date

Const. Bureau Date

Project No. I 90-2(32)67 U-1 C.O. No. 6

Rev. 5-1-73

Fig. II-12a

Transmitted to FHWA —

Approved by FHWA —

JONES CONSTRUCTION COMPANY

CONTRACTORS

Address Reply To:

Main Office: Helena, Mont. 59601

P.O. Box 20036
Helena, Montana 59601

State of Montana
Department of Highways
Missoula, Montana 59801

Re: Project I 90-2 (32) 67 Unit 1
Cement Freight Rate Adjustment

Gentlemen:

The cement used on this project was shipped from Trident, Montana to Frenchtown, Montana.

Article 09.025 - Freight Rate Adjustment states that if the materials are not shipped from the nearest available source, then compensation will be on the basis of the calculated increase in freight from the nearest available source. Therefore, since the cement was available from the Montana City Plant we are requesting a freight rate adjustment as calculated on freight from Montana City to Frenchtown.

The following are the cheapest combined freight rates at the time of bidding in November 1970.

	From Trident	From Montana City
Rail to Desmit Siding, Montana	$0.16/CWT	$0.13/CWT
Truck transfer from Desmit to Frenchtown	$0.10/CWT	$0.10/CWT
(As per Hughes Hauling, Nov. 4, 1970)	$0.26/CWT	$0.23/CWT

The following are the cheapest combined freight rates while shipments were made in the summer of 1972.

	From Trident	From Montana City
Rail to Frenchtown, Montana	$0.18/CWT	$0.15/CWT
Truck transfer from Frenchtown to Plant	$0.10/CWT	$0.10/CWT
(As per Dick Irvin, Inc.)	$0.28/CWT	$0.25/CWT

As can be noted above, the cheapest combined rate from Montana City to the plant at Frenchtown was also raised a total of $0.02/CWT. See BN (NP) Tariff No. ______________.

Therefore, in accordance with Article 09.025 the calculated increase in freight from the nearest source is $0.02/CWT.

Fig.II-12b

The 40,011,400 pounds used on the above project times the $0.02/CWT is $8,002.28. This extra money has been paid as shown by the previously forwarded receipted freight bills. Therefore, if you concur in this amount, we would appreciate payment on the next progress pay estimate.

Very truly yours,

JONES CONSTRUCTION CO.

XYZ:zz

cc: File (2)

NOTE: Attached to this letter should be copies of the Tariff referred to in the above letter or certified statements from the common carrier containing information that substantiate the figure quoted by the contractor.

If the material had been shipped from the nearest source then the invoices from the common carrier showing actual freight costs would also be included.

Fig. II-12c

II-18 Contractor & Highway Department Relations

18.00 References

Standard Specifications, Section 5, 7 and 8.
Construction Manual, I-03 and II-15.06.
Labor Compliance Manual.

18.01 General

Section I-03.06 describes the general attitude and conduct the engineer should keep in mind in his relations with the contractor. An engineer who deals openly and fairly with the contractor will make his own job of contract administration easier. The Resident Engineer will direct some of the work, interpret specifications, and handle controversies. If he informs the contractor as to how he will handle these matters and then performs as he says, good relations will be established.

The contractor is in the construction business to make money, but the engineer is in his line of work to assure that a job is properly constructed. It would seem then that the two parties to the contract have opposite goals in mind, but it does not necessarily follow that friction between these two need develop. It is entirely possible to get the job done properly by exercising firm control and sound judgment, all within the attitude of helpful cooperation between the contractor and the engineer.

18.02 Instructions to the Contractor

During the course of the work inspectors may have to give advise or information regarding specification requirements to various foremen or superintendents working for the contractor. Many times the contractor's representatives are not available near the site of the work. During the pre-construction conference the subject of who will act for the foreman or superintendent, in his absence, should be discussed and a decision reached. In minor and routine matters workmen may be directly advised of the specification requirement by the inspector if this is agreeable to the contractor. Usually a suitable arrangement can be made if the subject is discussed thoroughly and the difficulties of transmitting instructions are resolved before any dispute develops on the job.

State inspectors are to be diplomatic by asking, suggesting, or requesting rather than ordering. There is one very good reason for this, aside from the need of good human relations and that is that when an inspector orders the contractor to do certain work or to perform work in a certain manner, the inspector causes the State to be responsible for any unfavorable outcome of that work. The State is more interested in the end results than with the methods and equipment used to obtain the end result. All important matters pertaining to the contract, the special provisions, instructions to superintendents; foreman and laborers employed by the contractor; and other pertinent information should all be covered in the Preconstruction Conference. Section II-15-03.

Most contractors will have sublet specialty portions of the work to subcontractors. The contract specifications apply to the subcontractor equally as well as they apply to the prime contractor. However, the prime contractor is entirely responsible for all of the work, regardless of to whom portions have been sublet to. The inspector or engineer usually deals directly with the subcontractors unless his instructions are disregarded or a question of area of responsibility arises, in which case he should then contact the prime contractor. Instructions involving subcontractors or other contractors working adjacent to the project should be brought out in the preconstruction conference and during the course of construction as frequently as is necessary to assure proper communication and promote continued efficiency.

18.03 Labor Compliance

General provisions governing the employment and payment of persons engaged by contractors, subcontractors, and others to perform the contract work awarded by the State Highway Commission of Montana must be checked periodically by the Resident Engineer or his staff. Checking will not be limited to the mathematics of the payroll but will also require one spotcheck each week for the first four weeks and one spotcheck per month thereafter. Spotchecks should include the following:

a. Is the employees full name given?
b. Is his home address given at least on the first payroll when he reports for work?
c. Is his job classification complete enough to be checked against the contract minimum wage scale?
d. Has he been paid at least the minimum wage specified under the contract?

Detailed instructions governing the labor interviews, method of checking contractor's payrolls and various information is contained in the labor compliance manual to which the Resident Engineer is referred for guidance. Some of the highlights of a labor check, employee interview, and the requirements, both State and Federal, governing minimum wage and hour requirements are shown below.

1. Minimum wage and hour requirements are derived from State law and are applicable to all State Highway contracts awarded. They're also derived from the Federal Davis-Bacon Act and Contract Work Hours Standards Act which are applicable only to the contracts awarded for the construction of Interstate highways. The principle requirements contained in the above provisions are that all laborers and mechanics engaged in the work under contract must be paid not less than the minimum wage rates listed on the schedule contained in the contract and posted at the site of the work, and further, that they must also be paid at not less than one and one-half times their regular rate for all hours worked in excess of the eight per day and forty per week.

2. Full payment of all wages earned (Anti-kick back). Any contractor or subcontractor who induces any person to give up any of the compensation to which that person is entitled under the contract is committing a criminal offense and is subject to very severe penalties. Under the Anti-kickback Act regulations certain deductions, such as, income taxes, Social Security, health insurance premiums, and many others which are made for the benefit of the employee, are allowable. The above deductions are also allowable under State law.

   During the labor compliance interview the engineer should ask each laborer whether he has been paid in full, whether deductions are being withheld from his pay, whether any tool or equipment deductions have been made, and whether paychecks are readily negotiable. Replies should be recorded in the field book, kept specifically for that purpose, and the replies checked against the contractor's payroll records.

3. Non-discrimination. The Department of Transportation regulations relative to the Civil Rights Act of 1964 prohibits discrimination against any employee or applicant for employment because of race, creed, color, or national origin, and also applies to the selection and retention of subcontractors and suppliers. Montana statutes likewise prohibit discrimination against any employee or applicant for employment.

4. Labor Compliance Enforcement. The Resident Engineer is the primary party responsible for enforcement of contract labor provisions, but will be assisted in every respect by the Labor Coordinator-Economist Section of the Construction Division, Helena, to which queries, problems, and controversies should be referred.

   The following list describes some of the detailed enforcement duties required of the Resident Engineer for his staff.

   a. Conduct spot interviews with contractor's and subcontractor's employees, to review minimum wage and hour compliance features.

   b. Adjust questionable practices with the contractor or his job personnel when such practices are discovered or complaints have been registered.

   c. Examine the contractors' time cards, payrolls and other employment records where it appears that willful violations have been taking place. This check establishes the facts of the case.

   The importance of any labor interview is for correcting improper payment practices in the early stages of construction, to preclude extensive investigations, and payments of back wages. Labor violations are criminal offenses subject to fines or imprisonment or both. It is, therefore, necessary that a complete report regarding the apparent violations should be made to the Construction Engineer for referral, prosecution, or any further investigation necessary. It is not intended that the Resident Engineer act as a prosecuting attorney, rather it is his duty to make appropriate labor interviews, checks and proper referrals of controversies or exceptions that have been noted by him.

5. Conspicuous Posting of Labor Compliance Requirements.

   a. All Projects.

      1. Minimum Wage Schedule.
      2. "Dual Employment" Poster
      3. "Notice" of false statements by State and Federal employees.
      4. The "Non-discrimination" Clause on non-discrimination.

   b. All Federal Aid Projects.

      1. "Notice" of false statements by State and Federal employees.
      2. "Equal Employment" poster on non-discrimination.

   c. Federal-aid Interstate Projects.

      1. Form PR-809, "Important" poster on minimum wages.
      2. Schedule of minimum wage rates as determined by the Secretary of Labor.

II-19 CONSTRUCTION FORMS, RECORDS AND REPORTS

19.01 General

There are many forms and reports that must be completed by field personnel. The purpose of these reports is to satisfy certain specification requirements, authorize payment, document pay quantities and as required by Department of Highways policies.

A table of construction forms and reports that are required to be filled out by project and office personnel has been compiled. The table lists what forms are available, who is responsible to complete the forms, where information can be found for help in filling out the forms, the number of copies required and distributions. A table of construction forms used for notekeeping, staking and documentation of pay quantities is also shown.

The table does not show all forms and reports that must be completed by field personnel such as testing and materials forms, payroll, accounting, and right-of-way forms. Other manuals and memos should be consulted when filling out forms not listed. All of the forms required by the Construction Division are shown in the table.

TABLE OF CONSTRUCTION BUREAU FORMS AND REPORTS

Form No.	Name of Form	Purpose	Prepared By	No. of Copies & Distribution	Special Instructions or Notes about Form
C-1 Rev. 1-3-72	Notice to Contractor of Contractor proposal acceptance.	To notify the contractor that he has been awarded the contract. Required by Article 03.02 Standard Specifications.	Constr. Bureau Chief Helena	Shown on Form	--------------
C-2 Rev. 1-3-72	Notice to Start Assessing Contract Time	Shows date Contractor is expected to begin work and from which date contract time will be charged. Required by Article 08.02 Standard Specifications.	Constr. Bureau Chief Helena	Shown on Form	Effective approximately 20 days after contract is awarded.
C-3 Rev. 10-10-72	Order to Contractor to Suspend Work.	Work on the contract can not be suspended without written order from the Project Manager. Required by Article 08.03 Standard Specifications.	Project Manager	Shown on Form	See Article 15.04 Construction Manual
C-4 Rev. 10-10-72	Order to Contractor to Resume Work.	When work on the contract has been suspended and the engineer determines that work should be resumed, a written order is issued.	Project Manager	Shown on Form	See Article 15.04 Construction Manual
C-5 Rev. 10-10-72	Assessment for Minor Work	Form documents time that is assessed when contractor elects to perform work during time of suspension.	Project Manager	Shown on Form	See Article 15.06(c) Construction Manual
12 Rev. 11-61	"Extra Work" and "Extra Material" order (Force Account Basis)	Form documents and establishes the basis of payment for work not contemplated under original contract.	Project Manager	Original to Helena with all necessary supporting data	See Chapter II-17 Construction Manual

TABLE OF CONSTRUCTION BUREAU FORMS AND REPORTS

Form No.	Name of Form	Purpose	Prepared By	No. of Copies & Distribution	Special Instructions or Notes about Form
13 Rev. 3-71	Change Order	Documents changes in plans, specifications, eliminated items, agreed price changes, quantities of items, proposed equipment usage, specified materials and other allowed changes in the work as described in the contract.	Project Manager	Original to Helena with all necessary supporting data	See Chapter II-17 Construction Manual
21	Utility work Order	Utility Work Orders are used to document overruns and additional work required but not provided for under the original agreement. It is also used to document utility work required but not covered by a previous agreement.	Project Manager	Original to Helena with all necessary supporting data	See Chapter II Article 20-06 Construction Manual
7 Rev. 2-59	Utility Claim	Form documents utility relocation details, utility claims and railroad flagging costs.	Project Manager	Shown on Form	See Chapter II Article 20-05 Construction Manual
14	Estimate	The estimate form's purpose is to record the amount of work performed by the contractor during a certain time period and to determine the payment due the contractor for this work.	Project Manager	Shown on Form	See Chapter II Article 16-06 Construction Manual

TABLE OF CONSTRUCTION BUREAU FORMS AND REPORTS

Form No.	Name of Form	Purpose	Prepared By	No. of Copies & Distribution	Special Instructions or Notes about Form
C-8 10-13-66	Progress Estimate Work Sheet	Items for which an estimated amount must be determined for the progress estimates are calculated on work sheets. Examples are excavation and lump sum items. Work sheets then serve as documentation for these qualities.	Project Manager	Retained in Project File	See Chapter II-16 Construction Manual
	Comparison Sheet	Bid quantities are compared with Final Quantities and the differences shown.	Project Manager	Copy accompanies Final Estimate	See Chapter II-16 Construction Manual
C-3(A) 1-7-71	Non-Assessable Contract Time	Notice to contractor no time will be charged to the project from Nov. 15 thru April 15 of the following year.	Project Manager	Shown on Form	See Chapter II Article 15-06(B) Construction Manual
	Explanatory Notes	Explains the reasons for differences in bid quantities and final quantities.	Project Manager	Copy accompanies Final Estimate	See Chapter II-16 Construction Manual
PR-47 Rev. 3-72	Statement of Materials and Labor used by Contractors on Highway Construction involving Federal Funds	Completed form is required before F.H.W.A. can make final acceptance of a project. It is used for tabulating Nationwide cost indexes. Form PR-47 not required for Secondary projects or grade crossing projects.	Division Constr. Supervisor	Original to Helena	Part A completed by Division Construction Supervisor. Part B completed by Contractor. See Chapter II Article 16.06D Construction Manual

TABLE OF CONSTRUCTION BUREAU FORMS AND REPORTS

Form No.	Name of Form	Purpose	Prepared By	No. of Copies & Distribution	Special Instructions or Notes about Form
Rev. 1-3-71	Certificate of Completion of Construction Contract	By means of this form the Contractor is officially notified that a final inspection has been made and that the work under his contract is complete and accepted. Required by Article 05.15 Standard Specifications.	Division Constr. Supervisor	Shown on Form	See Chapter II Article 16.07 Construction Manual
No Standard Form	Mileage Comparison	Informs Preconstruction of changes in actual length of project. Subsequent projects can be planned accordingly.	Project Manager	Three copies with Final Estimate	Required on paving and grading projects even though no mileage change occurred.
No Standard Form	Gravel and Borrow Pit Reports	Report providing information to designers of future projects about sources of material and amounts available.	Project Manager	Five Copies with Final Estimate	See Chapter II Article 16.06D Construction Manual
R/W Form 37B	Pit Release Statement	Form certifies that all conditions set forth in pit agreement have been met and State and Contractor are released from any further obligation.	Project Manager Signed by owners and Project Manager	One copy kept in Division. One copy to Helena R/W and Helena Construction	Forms must be completed on all State optioned borrow or gravel pits. Not necessary on pits Contractor has secured.
158	Report of Completion of special authorization	This form is used when material is taken over by the State from the Contractor and placed in States stores.	Division Constr. Supervisor	Three copies to Helena Maintenance Division	See Chapter II Article 16.06C Construction Manual

Form No.	Name of Form	Purpose	Prepared By	No. of Copies & Distribution	Special Instructions or Notes about Form
C-P-2 Rev. 7-1-72	Project Personnel Assignment Authorization (to be used on permanent change of residence from one Division Hdqts. to another or to Helena Hdqts.	Form authorizes Accounting Division to make payment for expenses.	Division Constr. Supervisor	Shown on Form	See current permanent residence and field expense policy.
P-2 Rev. 7-1-68	Overtime	Form authorizes payment of overtime when employees must work overtime to coincide with contractors operation and provide construction supervision.	Division Constr. Supervisor	Shown on Form. See special note on Form	See Personnel Manual for overtime regulations.
P-3 6-54	Personal Vehicle Hire	Form authorizes payment for hire of personal vehicle when State-owned transportation is not available.	Division Constr. Supervisor	Shown on Form	Other forms must accompany Form P-3. See note on form.
L-1	Equipment Rental	Form is required when contractor contemplates use of rental equipment. Required by Article 08.01C Standard Specifications.	Contractor and submit to Project Manager	One copy retain in project file. One copy to Helena	Use of form is optional. Information may be submitted on Company letterhead.
LC-1	Employees Spot Check Interview	Form is used to record information found in spot check interviews made to determine compliance with labor provision of contract.	Project Manager	One copy retain in project file. One copy to Helena	See Article 515-4.6 of Labor Manual

TABLE OF CONSTRUCTION BUREAU FORMS AND REPORTS

Form No.	Name of Form	Purpose	Prepared By	No. of Copies & Distribution	Special Instructions or Notes about Form
LC-2	Labor Complaint Form	Information on form is used in investigation of labor complaints.	Contractor Employee submit to Engineer	One copy to Helena	See Article 515-4.7 of Labor Manual
LC-3	Engineers Payroll Check List	Used by Project Manager as check to determine compliance of payroll with contract provisions.	Project Manager	Original attached to weekly payroll submitted to Helena	See Article 515-4.3 of Labor Manual
LC-4	Preconstruction Conference Attendance Records	Form is used to record those in attendance at preconstruction conference.	Office Engineer	One copy to Helena. One copy to firm or organizations attending meeting	See Article 401.1 of Labor Manual
1	Montana Dept. of Highways Constr. Inspection Report	Information Form & Record of inspections made by Construction Bureau personnel visiting project.	Person making inspection	To Construction copies to those required to take action	---------------
80	Monthly Inventory of Equipment not on Rental Basis	Keeps Division Construction Supervisor informed as to location, condition and amount of engineering equipment and supplies on hand.	Project Manager	One copy kept in Project Manager's file. Two copies to Division	Form is used to compile information for semi-annual inventory submitted to Helena.
Rev. 6-30-68	Semi-annual Report of Engineering Equipment on Constr. Division Inventory	Account for equipment and record changes in disposition of same.	Compiled by Division Office	One copy to Helena	Submit on June 30 and December 31 of each year.

Form No.	Name of Form	Purpose	Prepared By	No. of Copies & Distribution	Special Instructions or Notes about Form
2	Daily Report of Material Produced	Form provides daily record of aggregate produced and is a convenient form to determine daily total.	Scaleman	No copies required. Original placed in project file with weigh tickets	---------------
R/W Form 72-Rev. 4-68	Permission to enter on Private Property	Form authorizes entry by engineering crews onto private property.	Project Manager or R/W Personnel signed by landowner	One copy retained by Division	---------------
C-P-1 Rev. 8-1-69	Project Personnel Assignment Authorization (to be used for assignment to a project on temporary or permanent basis).	Form authorizes Accounting Division to make payment for expenses.	Division Constr. Supervisor	Shown on Form	See current permanent residence and field expense policy.
LC-8	Payroll Register	Form is used by Project Manager as convenient way to check status of weekly payroll submissions.	Project Manager or as designated	Kept in Project Files	Form is used for each prime and subcontractor on project.
C-6 Rev. 3-72	Contractors Report of Motor Fuel purchased other than gasoline.	Contractor reports amount of fuel purchased and amount of tax due. Required by State Law.	Contractor	One copy to Helena	See Instructions on Form

TABLE OF CONSTRUCTION BUREAU FORMS AND REPORTS

Form No.	Name of Form	Purpose	Prepared By	No. of Copies & Distribution	Special Instructions or Notes about Form
58	Weekly Progress Report (Still required in some Divisions)	Report informs those not directly involved with project on the progress being made. Items completed personnel on job etc.	Project Manager	Original to Division Constr. when required	Division Policy Dictates
No Stand. Form	Progress Report	Division Construction Supervisor uses information from Progress Report to prepare composite report submitted to Helena.	Project Manager	Original to Division Constr. Supervisor composite to Helena	See Chapter II Article 19.02 Construction Manual
No Stand. Form	Report of start of a major phase of work	Report notifies Helena that construction has started on a major phase of a project.	Division Constr. Supervisor	One copy to Helena	Report should be made when work starts on utilities, grading, aggregate surfacing and plant mix surfacing
CSN-40A Rev. 9-72	Reclamation Plan for Open Cut or Strip Mining Operation	A reclamation plan is required prior to commencing any operation for the removal of 10,000 C.Y. or more of any material. Article 06.02 Standard Specifications.	Contractor submits to Project Manager	Copy to Helena for approval by agencies concerned	See Chapter II Article 21.02 Construction Manual
	Affidavit	Affidavit releases the Department of Highways from reclamation responsibility to the landowner.	Project Manager R/W and signed by owner	Forwarded to Dept. of State Lands	See Chapter II Article 21.10 Construction Manual

Form No.	Name of Form	Purpose	Prepared By	No. of Copies & Distribution	Special Instructions or Notes about Form
CSN-01	Construction Staking Form	Used for recording all original and remeasure cross-section notes.	Instrument-man or Note Keeper	Kept in Project Files as permanent record.	See Chapter III Construction Manual
CSN-02	Basic Notekeeping Form	Used to record notes for most contract pay items and also for transit notes, etc.	As designated by Project Manager	Kept in Project files as permanent record.	See Chapter IV Construction Manual
CSN-03	Direct Solar Observation	Used for recording notes when making direct solar observations.	Note Keeper	Kept with other notes of location survey.	On the Form
CSN-05A 05B 05C	Parallel Spiral Curves	Explanation of computations for parallel spiral curves and examples.	-------	-------------	-----------------
CSN-06	Lined Notepaper	-----------------------	---------	---------------	--------------------
CSN-12	Statement of Daily Force Account Work	Daily record of all labor, equipment and material used on force account basis is recorded on this form.	Project Manager or Inspector	Kept in Project Files as permanent record.	Form must be signed at end of last shift by Inspector & Contractor. See Chapter II Article 17.05F Construction Manual
CSN-50	Rolling Equipment Record	Form is used to document all rollers on project when rolling units is a pay quantity. Unit values are recorded on this form.	Project Manager or Inspector	Kept in Project Files as permanent record.	See Standard Drawings No. 13-01 and 13-02

TABLE OF CONSTRUCTION BUREAU FORMS USED FOR
NOTEKEEPING, STAKING AND DOCUMENTATION OF PAY QUANTITIES

Form No.	Name of Form	Purpose	Prepared By	No. of Copies & Distribution	Special Instructions or Notes about Form
CSN-51	Rolling Record	Data from rolling card is entered on this form and running total of rolling units is computed for pay quantity purposes.	As designated by Project Manager	Kept in Project Files as permanent record.	See Standard Drawings No.13-01 and 13-02. Refer to Form CSN-51 for roller unit value.
	Rolling Card	Documents number of rolling hours for each roller per shift. Data is entered on Rolling Record.	As designated by Project Manager	Kept in Project Files as permanent record.	Must have Inspectors written signature.
	Water Punch Card	Documents amount of water delivered to project by each truck per shift. Data is entered on Water Record.	As designated by Project Manager	Kept in Project Files as permanent record.	Must have Inspectors written signature.
CSN-54	Water Record	Data from water punch card is entered on this form and running total of water computed for pay quantity purpose.	As designated by Project Manager	Kept in Project Files as permanent record.	Must have Inspectors written signature.
124	Gravel Ticket	Documents amount of material delivered to project by each hauling unit.	As designated by Project Manager	Kept in Project Files as permanent record.	White-Contractor copy. Scaleman & Rodman validate. Yellow-Road copy. Scaleman & Roadman validate. Pink Scaleman copy, Scaleman validate. Written initials required for all copies.

TABLE OF CONSTRUCTION BUREAU FORMS USED FOR
NOTEKEEPING, STAKING AND DOCUMENTATION OF PAY QUANTITIES

Form No.	Name of Form	Purpose	Prepared By	No. of Copies & Distribution	Special Instructions or Notes about Form
5	Gravel Punch Card	Documents amount of materials delivered to project by each hauling unit.	As designated by Project Manager	Kept in Project Files as permanent record.	Used when hauling units are loaded uniformily 2 cards are retained for validation & documentation. One card signed by scaleman and one by roadman, requires written signatures.
	Traffic Control Card	Documents amount of traffic control items used by contractor during shift.	As designated by Project Manager	Kept in Project Files as permanent record.	Form must be signed at end of last shift by Inspector and Contractor.
CSN-25	Culvert Note Form	Form used to record information pertinent to staking and inspection of culverts.	Instrumentman or note keeper and culvert inspector	Kept in Project Files as permanent record.	See Chapter IV Construction Manual.
CSN-55	Blasting Record	Form is used to record method, location of blast area, amount and type of equipment and materials used.	As designnated by Project Manager	Copy to Helena to Geology Section	See Chapter IV Construction Manual. Article 41-04

137
CONSTRUCTION
OFFICE MANAGER

19.02 Progress Report

A. General

Progress reports serve an important need of informing individuals not directly related to a Division, of the activities expected to be undertaken, work done and of events that have happened during the reporting period.

Reporting periods will be the first and third Monday of the month during the construction season and first Monday only of the months December, January, February and March. Each Division is to establish a date by which all progress reports for Preconstruction and Construction projects are to be received. These will then be compiled into one progress report for the Division. Helena needs the composite progress report by Monday morning so they should be mailed from Division no later than the preceding Friday.

Sometimes progress reports do not arrive in Helena in time for distribution. Naturally there are many good reasons why Helena does not receive them. Sometimes the mail is late and sometimes the Division Office isn't on the ball. Progress reports are almost always on time but if they don't arrive on time for publication, Helena likes to poke a little fun at the Division, by inserting a cartoon in the place of the missing report.

The format, for the composite progress report submitted by the Division, used successfully for sometime now by each Division, is to be continued. It is presented below, in outline form, as an example.

MONTANA DEPARTMENT OF HIGHWAYS
(City), Montana
Date and Year

Montana Department of Highways	Progress Report
Helena, Montana	Area

Gentlemen:

The following is submitted covering construction and preconstruction operations in (City) Division for the period ending ______________________________.

GENERAL

Describe the general construction activities, weather conditions, or their effects throughout the Division.

PRECONSTRUCTION

(Project No. and Designation)
Length ___________ Miles
Survey Started (Dated)

(Name of Project Manager in charge) (Address)
Estimated Completion Date

Description of type of work underway (or status of the job if no work is underway). Number of men working and where, number of man days used and total to date, percent complete, status of work of utility company and conflicts with contractor or other utilities, date survey completed, date mailed to Helena, and other useful information that is timely.

CONSTRUCTION

(Project No. and Designation)
Length ___________ Miles
(Type of Work)
Contract Awarded (Date)
Amount of Contract $____________

(Contractor's Name)
(Address)
(Project Manager's Name)
(Address) (Phone No.)
Contract time (No. of calendar days or completion date) or No. of days after notification
Prob. Completion Date________

Proceed Order Date _________
Work Started________________

The following list shows some of the details that are needed, when applicable, in the progress report.

Describe the type of work in progress, reasons for poor progress, number and length of shifts worked by contractor, construction layout, percent complete, quantity of work done on each major item, future plans of contractor, condition of PTW and detours, date of seasonal suspend work order, percent of contract time used, number of days remaining, percent of contract complete, status of utility work remaining and report of conflict with contractor or other utilities, status of final estimate showing percent complete, number of men working on it and estimated submittal date.

DIVISION CONSTRUCTION SUPERVISOR

(City) (Division) (Page Number)

Upon receipt of a staking authorization, please start including the project in the Preconstruction Section of the Progress Report, stating the percentage of construction layout complete to date each period, as well as a resume of the work done during the period.

As soon as a project is awarded it is to be included in the Construction Section of the progress report regardless of whether work has started or not.

Show a probable completion date for each construction project including calendar date projects. Sometimes it is difficult to arrive at such a date, but state your best estimate for each reporting period.

After completion of a project, please include an estimated date in every report as to when the final estimate will be forwarded to Helena. Again, state your best estimate as of each reporting period.

All probable and estimated dates stated should be reviewed for possible revision and correction.

Please do not overlook the numbering of the last sheet of the Progress Report.

B. Progress Reports - Bridge Construction

The most important bridge construction information you can show on the weekly progress report, and that which the Bridge Division is seeking, is what work was done on the job during the reporting period.

Below are some of the important items that pertain to bridge projects which should be reported.

1. The structure excavation in progress?
2. The pile driving in progress?
3. What forming work is in progress?
4. What concrete was placed?
5. What reinforcing steel was tied and placed if concrete was not placed around it?
6. What beams or structural steel were erected?
7. What effect, if any, did the weather have on the work?
8. How many shifts were worked and what was the average number of men per shift?
9. Show the percentage of the project completed.
10. Show the number of contract calendar days used to date as well as the percent of contract time elapsed.

Please continue to send a copy of the Project Manager's progress report directly to the Construction Bureau and the Bridge Section.

19.03 Retention of Records

The Federal Highway Administration reviews and audits certain Federal Aid Projects and occasionally finds that some Department of Highway Offices are not acquainted with the Federal Highway Administration requirements relative to record retention. Source records in some instances were destroyed too soon and are not available for audit.

The requirements for record retention are set forth in Policy and Procedure Memorandum 30-9 dated March 31, 1972. Section 2, states in part:

> "The project related records defined in paragraph 3a and listed in Appendix A, attached, are to be maintained or caused to be maintained by the State. Complete project documentation and maintenance of adequate records (including source data) to support a State's claim for reimbursement is the responsibility of the State Highway Department."

Paragraph 3a as referred to above reads:

> "Records. Includes all accounts, papers, maps, photographs, or other documentary materials, regardless of physical form or characteristics, made or received by any agency, firm, or individual in connection with the transaction of Federal Aid Highway business and preserved or appropriate for preservation as evidence of their organization, functions, policies, decisions, procedures and operations or because of the informational value of data contained therein."

Periods of retention vary according to record type and relation to the project. Project oriented records (Project file generally) may be destroyed after three years with FHWA permission.

Financial and accounting records are to be retained for four years before destroying. Again FHWA permission is required before the record can be destroyed.

Appendix A of PPM 30-9 describes in detail the types or records and their respective retention periods. Care must be taken to insure that all necessary records are retained as required by PPM 30-9.

SAMPLE FORM FOR LUMP SUM BILLINGS

TO: STATE HIGHWAY COMMISSION OF MONTANA

NAME: MONTANA POWER COMPANY
(Utility Company)

ADDRESS: HELENA, MONTANA

Cost of rearranging facilities because of construction of Highway Project:

Number F-77(15)

Work Order Number 7-12959

Work Started February 5, 1968 Completed March 4, 1968

We hereby submit our bill which covers our agreement with the State of Montana

dated December 22, 1968 which is on a Lump Sum basis.

Net Amount This Claim $707.00

CERTIFICATION

I certify that this claim complies with the State agreement and the Bureau of Public Roads' Policy & Procedure Memorandum 30-4 in that MONTANA POWER COMPANY constructed the most economical type of facilities in the new location that would satisfactorily meet the same service requirements of the old facilities in the old location.

Also, I certify that this claim is correct and just in all respects and that payment or credit has not been received.

Dated March 26, 1968 Signed /s/ Verne W. Brown
By:
Title: Division Superintendent

X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X
(Leave Space for Utility and Commission Approvals)

NOTE: The above form is the correct statement to be used when submitting bills on Lump Sum Agreements of $5,000.00 or less.

Please submit eight (8) copies to State Highway Division that authorized work.

Fig. II-12

SAMPLE FORM FOR PROGRESS BILLINGS

Ref: (PPM 30-3 & 30-4)

TO: STATE HIGHWAY COMMISSION OF MONTANA

NAME: MOUNTAIN STATES TELEPHONE
(Utility Company)

ADDRESS: Salt Lake City, Utah

Supporting Statement to bill for adjustment of facilities required by Construction of Highway Projects.

Progress Billing Number 3

Project Number F 107(10) I.C. F 107(12) Const.

Work Order Number M-8-0506 Work Started December 18, 1967

Period of Progress Billings May, 1968

Labor & Equipment Costs	$ 6,546.00
Materials Costs	$ 16,495.00
Miscellaneous Expense (Including payment to approved Contractors)	$ 22,190.00
Materials Credits	$ (19.00)
Total Claim to Date	$ 45,212.00
Less 10% Retention	4,521.00
Sub-Total	$ 40,691.00
Less Previous Billing	$24,133.00
Total Amount Claimed this Billing	$ 16,558.00

I certify that this claim is correct and just in all respects and that payment or credit has not been received.

July 5, 1968
(Date)

Payee MOUNTAIN STATES TELEPHONE & TEL.COMPANY
(Utility Company)

By J. B. DePlazes
(Designated Company Representative)

X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X
(Leave Space for Utility and Commission Approvals)

NOTE: *Amount claimed cannot exceed 90% of the Agreement. Approved utility work orders are also eligible for 90%.

Submit eight (8) copies to State Highway Division that authorized work.

*State's portion of the agreement and utility Work Order.

FIG.II-13

CONST. FORM 7
(Revised 2-59)

INTER-DEPARTMENTAL MEMORANDUM

STATE HIGHWAY COMMISSION OF MONTANA

From [redacted] Division Engineer

Date March 11, 1968

To CONSTRUCTION ENGINEER, HELENA

Subject: UTILITY CLAIM

F-FG 270(18) I.C.
PROJ. NO. F-FG 270(19) Const.

UTILITY COMPANY MONTANA-DAKOTA UTILITY COMPANY

ADDRESS Williston, North Dakota

WORK STARTED October 3, 1966

WORK COMPLETED October 18, 1967

AGREEMENT DATE July 27, 1966

AMOUNT $2,000.00 Agr.
$1,181.80 States

CLAIM AMOUNT $1,327.58

(FINAL -- ~~PROGRESS~~)

OVERRUN AMOUNT $145.78

COVERED BY U.W.O. NO. One

REMARKS: 100% credit was given for salvage as all poles removed were in A 1 con

One 60' and one 75' pole were installed temporarily to provide clearance while embankment was being constructed. These were later removed and 50' poles installed on the inslope to shorten the span and provide necessary clearance.

The following is original and new locations of facilities moved:

ORIGINAL LOCATIONS			NEW LOCATIONS		
Station	Distances	Remarks	Station	Distances	Remarks
203+00	83' Rt.	Private R/W Salvage 40' Pole	203+24	81' Rt.	New 75' Pole
			250' E. of above Sta.		New 50' Pole
500' E. of Sta. 203+24		Private R/W Salvage 40' Pole	500' E. of above Sta.		New 50' Pole
205+12	30' Lt.	Private R/W Salvage 40' Pole	205+12	32' Rt.	New 50' Pole
290' W. of above Sta.		Private R/W Salvage 40' Pole	290' W. of above Sta.		New 60' Pole

SUBMIT IN TRIPLICATE TO
CONSTRUCTION DEPARTMENT

/s/ [redacted], Resident Engineer

Avoid Verbal Instructions

FIGURE II-14

CONST. FORM 7
(Revised 2-59)

INTER-DEPARTMENTAL MEMORANDUM

STATE HIGHWAY COMMISSION OF MONTANA

From [redacted], P.E., Division Engineer

Date March 11, 1968

To CONSTRUCTION ENGINEER, HELENA

Subject: UTILITY CLAIM

PROJ. NO. I-IG-15-2(10)125 U-1

UTILITY COMPANY CITY OF BUTTE

ADDRESS City Hall, Butte, Montana

WORK STARTED September 25, 1967

WORK COMPLETED

AGREEMENT DATE March 24, 1967

AMOUNT $22,000.00 Agr.
$18,231.73 State

CLAIM AMOUNT $5,697.55

(~~FINAL~~ -- PROGRESS) No. 3

OVERRUN AMOUNT

COVERED BY U.W.O. NO.

REMARKS: Prog. No. 1, Amt. $5,511.14 submitted November 9, 1967
Prog. No. 2, Amt. $5,854.70 submitted December 19, 1967
Prog. No. 3, Amt. $5,697.55 Total To Date $17,063.39

The following is original and new locations of facilities moved:

ORIGINAL LOCATIONS			NEW LOCATIONS		
Station	Distances	Remarks	Station	Distances	Remarks

Pole data and sketch to accompany final report.

SUBMIT IN TRIPLICATE TO
CONSTRUCTION DEPARTMENT

/s/ [redacted], Resident Engineer
Avoid Verbal Instructions

FIGURE II-15

CONST. FORM 7
(Revised 2-59)

INTER-DEPARTMENTAL MEMORANDUM

STATE HIGHWAY COMMISSION OF MONTANA

From [redacted] P.E., Division Engineer

Date January 31, 1968

To CONSTRUCTION ENGINEER, HELENA

Subject: UTILITY CLAIM

PROJ. NO. F-8(8) U-1

UTILITY COMPANY Great Northern Railway Company

ADDRESS St. Paul 1, Minnesota

WORK STARTED October 2, 1967

WORK COMPLETED October 30 1967

AGREEMENT DATE January 11, 1967 Agr.
January 31, 1967 Det.Est.

AMOUNT $9,600.00 *(2400 hrs.)

CLAIM AMOUNT $545.83

(~~FINAL~~ -- PROGRESS) No. 7

OVERRUN AMOUNT

COVERED BY U.W.O. NO.

REMARKS: NO FACILITIES INVOLVED

*See Proj. Spec. Prov.

Const. Form 7 - F-8(9) U-1, Amt. $252.45 - 74 hrs. - October - Bill

The following is original and new locations of facilities moved:

ORIGINAL LOCATIONS			NEW LOCATIONS		
Station	Distances	Remarks	Station	Distances	Remarks

Prog. No. 1, Amt. $287.15 - 93 hrs. - April 1967
Prog. No. 2, Amt. $177.81 - 56 hrs. - May 1967
Prog. No. 3, Amt. $ 73.14 - 22 hrs. - June 1967
Prog. No. 4, Amt. $404.12 -125 hrs. - July 1967
Prog. No. 5, Amt. $257.03 - 78 hrs. - August 1967
Prog. No. 6, Amt. $393.92 -112 hrs. - September 1967
Prog. No. 7, Amt. $545.83 -160 hrs. - October 1967
TOTAL TO DATE - $2,139.00 - 646 hrs.

SUBMIT IN TRIPLICATE TO
CONSTRUCTION DEPARTMENT

FIGURE II-16

/s/ [redacted], Resident Enginee

Avoid Verbal Instructions

II-20 UTILITIES

20.00 References

Standard Specifications: Articles 05.05 and 07.16

20.01 General

In general, the policy is to require the relocation of utility facilities from within certain limited access rights of way and those highway construction projects where the existing facility will conflict with road or bridge construction. Utility facilities may be permitted within the right-of-way of crossroads and carried over or under limited or controlled access highways, provided that servicing can be accomplished without access from the roadway or ramps.

No poles or structures will be permitted within the limited access right-of-way limits which will require utility construction or maintenance personnel or equipment, to operate from the right-of-way after the highway is open to traffic.

Utilities within the construction area are publicly or privately owned. The contractor is responsible for damage to these facilities caused by his operations regardless of whether they are shown on the plans. It is quite probable that some of these utilities have been relocated since the plans were prepared and consequently the locations shown may be incorrect, however, the contractor is still liable for damage due to his operations.

Utilities are generally adjusted or replaced by the following methods:

1. By the owner with his own forces.
2. By the owner under his own contract.
3. By the State under separate contract before the highway construction contract.
4. By contract items or extra work under the Highway contract.

There are some instances where a utility facility is overlooked because of inactivity of the company, utility changes made after design or other reasons. These facilities are usually discovered during construction and require immediate attention to avoid delay to the contractor's operation.

20.02 DEFINITIONS

The following listed definitions describe terms and phrases frequently used in utility relations.

1. Utility shall mean and include all privately, publicly or cooperatively owned facilities consisting of electrical energy, oil, gas, water including sewer, steam and other pipe lines. Dependent upon the meaning intended in this manual, the term "utility" may also mean the utility company, inclusive of any wholly owned subsidiary.

2. Reimburse shall mean that State or Federal funds may be used to "pay back" the utility to the extent provided by law.

3. Costs of Right-of-Way shall mean the costs of land required for the relocation of the utility facility.

4. Preliminary Engineering shall mean and include locating, making of surveys and the preparation of plans and estimates prior to execution of agreement.

5. Construction shall mean the actual building and all related work including utility relocation or adjustments.

6. Salvage Value is the amount received by the State for the sale of utility property removed or, if retained for re-use, the amount at which the material recovered is charged to the materials and supplies account.

7. State as referred to herein shall mean the Department of Highways.

8. Authorization shall mean written authorization from the State to the utility to proceed with any phase of a project.

9. Betterments are any increase in value or of size or functional capacity of service improvement in the facility being relocated or adjusted, over and above that required by the highway construction.

10. Overhead Costs are those costs which are determined by applying a rate or percentage factor to labor for pensions, relief, insurance and taxes; costs for general engineering, supervision and general office services by the utility or its contracts for this work; or other means that will provide a fair distribution of actual but reasonable overhead costs to specific relocation jobs. Actual costs for labor, materials and equipment are not overhead costs.

20.03 Authorization for the Work

After award and execution of the highway contract or utility contract and after all permits to construct within highway right-of-way are authorized, the Department of Highways will notify all pipeline companies, utilities or other affected parties to assure that all necessary utility adjustments, etc., are made as soon as practicable. This written notification is to be made by the Division Construction Supervisor and may be an invitation to attend the general Preconstruction Conference or a specific utilities preconstruction conference. See Article 20.08 (B) General Records for additional information.

"Exhibit A" of the Utility Agreements have wording such as "We estimate that it will take us 22 weeks to complete the work after we are advised the centerline and right-of-way line stakes are in place and we are authorized to proceed".

A serious delay can be caused in getting utilities moved if we have not notified them that ℄ and R/W stakes are in. Please read each utility agreement carefully then be sure you are carrying out the Department of Highways end of the agreement. This responsibility rests with the Division Supervisor.

20.04 Project Manager's Responsibility

The Project Manager should study the plans special provisions, specifications and existing agreements and become familiar with any encroachment permits or other negotiations of any nature which will affect utility relocation or reconstruction. If permits to construct within the highway right-of-way have not been acquired, he must make immediate arrangements to obtain these, as no utility construction may be authorized or pursued without first applying for and obtaining a permit authorizing such construction. Proposed utilities installations must be reviewed for possible conflict with either grade or line or with proposed construction such as footings, piers, electroliers, pile driving, etc. In most cases, good planning and coordination can prevent installation of facilities closer to the highway than safety standards dictate. The following instructions will govern.

1. As a general objective, facilities which project above the ground should not be placed closer than 30 feet from the edge of the traveled lanes on any main line, frontage road or Present Traveled Way.

2. Project Managers or other field personnel, having charge of utility relocations on a project should coordinate closely with utility personnel at the time that final engineering by the Utility is completed. Any installations in conflict with Item No. 1 above should be reviewed very carefully and every effort made to resolve the problem.

3. Where no reasonable alternative to avoid placement of facilities too close to the traveled way can be found, the matter should immediately be reviewed with the Division Construction Supervisor.

4. Review of usually complex or serious problems may be accomplished by the Chief, Construction Bureau and Manager Utilities Unit.

20.05 Utility Claims

Utility claims are used to reimburse utility companies for normal costs incurred in moving their facilities, on projects to be constructed, under construction, or completed. Costs involving changes or unanticipated problems are discussed in this manual under Utility Work Orders, Section 20.06.

All utility claims are to be submitted to the Construction Bureau, Helena, after thorough review and checking by Division Staff.

A. Checking and Submittal of Claims

(a) Submit seven (7) permanent copies of the actual detailed costs or lump sum bills presented by the utility. The second copy is to be thoroughly checked accurately coded and initialed by the checker. The Division Construction Supervisor is to sign or initial the checked and coded copy in spaces provided on the coding stamp imprint.

(b) Check the format for the Following: Correct project numbers, name and address of the utility company actual starting and completion dates, agreement date and amount. (see Fig II-13) If the format is incorrect, resubmit it to the Utility Company requesting the necessary information be furnished on that and future claims.

(c) Certification required by PPM 30-4 and State law. The claim must contain or have attached, a certification that the Utility company provided the most economical type of facilities in their new location and that the new facilities satisfactorily meet but do not substantially improve the service functions, sizes or capacities of the old facilities in their old location.

(The aforementioned certification is not required when relocation is governed by PPM 30-3).

State law requires the following certification to be on or attached to all claims presented by a Utility Company.

"I certify that this claim is correct and just in all respects, and that payment or credit has not been received."

Date ____________________ Payee ______(Company)____________________

By ______________________ Title ______________________________________

B. Construction Form 7 (Revised June 1973)

Three (3) copies of this form, used for utility relocation details, progress billings, railroad flagging costs and energy bills are to be completely filled in accordance to the following instructions, signed by the Project Manager and submitted to the Construction Bureau, Helena.

(a) Various details of a typical Utility Relocation are shown in Figure II-15. This form is to be complete regarding such details as; date, project number with geographical designation (I.C. & Const.), Name and address of Utility Company, actual starting and completion dates, ete.:

(1) Information to be placed under Original Location and the New Location of the facility moved is: Stations on centerline; Distances right or left of centerline; length, class and size of poles; length gage, and size of pipe lines.

State if the material is new or old, when new locations are involved.

Under the heading Original Locations state whether the structures were located on Private or Public Right-of-Way.

(2) A straight line diagram, for all utility moves is to be included on Construction Form 7 to identify the various project breakdowns of rural and municipal, F and FG, I and IG, etc.

(3) The engineer in charge or the Division Utilities Agent must conduct sufficient inspections and maintain adequate records as the work progresses that all work included in the claim was actually accomplished and attest to this fact with his signature, title and date. Work overruns must be carefully documented by inspections by the Project Manager or his representative as the work progresses. (See Sec. 20.08)

(4) A tabulation by pole count or pipe length showing the total money separated into the proper project breakdown is, rural and municipal, 2-lane, 4-lane, F & FG and I, IG.

(b) Progress Billings for utility relocation work are to be placed on Construction Form 7 (as shown in the example in Figure II-16) when work is progressively done and when the completed relocation data will be submitted in a final utility report.

(1) Progress bills may be submitted by the Utility Company, as the work progresses. Payment can be made up to the total amount of the State's obligation of the agreement amount, less a retainage of 10% times the billing total. This retainage amount must be held until an audit of the actual billings under the agreement is satisfactorily completed and the retained monies released. (see figure II-14)

(2) The information required under Original and New Locations may be waived for each progress billing until submittal of the final billing.

(3) A statement that locations and sketches of the original and new utilities will accompany the final billing, must appear on each progress billing.

(4) A chronological list of the progress number, amount and total to date, as shown in the example on Figure II-16 must be placed on Construction Form 7 or be attached to this form for each progress billing.

(c) Railroad Flagging and Energy Bills, both progress and final, are to be submitted on Construction Form 7 similarly to the example shown on Figure II-17.

(1) The agreement date can be either the actual railroad company's agreement date, or the Detail Estimate date, or both.

(2) The amount should be the State's obligation amount.

(3) Each progress billing must show a chronological listing (similar to the example on Figure II-17) of each progress number amount, hours used and the total to date.

(4) Railroad flagging charges incurred because of the contractor's operation and as provided in the Special Provisions are chargeable to the actual construction project on which the work was done. These charges are to be coded to Account Number 9502.

(d) One copy of a sketch showing utility location and relocation details is to accompany submittal of Construction Form 7 on 8½ x 11 or 8½ x 13 inch paper. The sketch can be a straight line diagram, but need not be to scale. The sketch must show details as:

1. The original and new utility relocations.
2. Original locations - public or private right-of-way.
3. The distances of the new right-of-way line right and left of center line.
4. The location of original right-of-way lines if available.

20.06 Utility Work Orders

A. General

All utility work orders must contain a description of the proposed work. Utility work orders are required when any of the following conditions exist.

1. When the original agreement does not adequately describe all of the work necessary to complete the relocation.
2. When utility work is necessary and there is no previous or original agreement with the utility company. A sketch showing the original and revised locations of the facility must accompany the work order. (See figure II-18).
3. When the actual work differs from the work as planned on Lump Sum Agreements.

4. Utility work orders are required when the amount of the final claim exceeds the original agreement by the following percentages.

Amount of Original Agreement From	To	Allowable Overrun Before Work Order Required
$ 0	$1,000	75%
$1,001	$5,000	$500 & 25%
$5,001	$10,000	$750 & 20%
$10,001	up	$1,750 & 10%

(B) Prior Approval of Utility Work Orders

Before performing relocation, adjustment, removal or similar work, this necessary work must be described in a Utility Work Order. The work order is then submitted for review and approval by the Construction Bureau who will obtain Federal Highway Administration approval. The approved work order or a notice of approval must have been received by the engineer initiating it before any work may begin.

Prior approval may be immediately necessary to perform work of an urgent nature. Where time is of the essence, prior approval may be obtained by teletype or telegram. Regardless of which method is used, written confirmation must document the approval. This documentation is to be a memorandum in the case of approval by radio, telephone or other verbal means, whereas if the telegram or teletype is used in transmitting approval each will serve as its own documentation.

The date of discussion with the Federal Highway Administration and the name of the Federal Highway Administration Engineer involved is to be placed in the lower right-hand corner of the description frame. The Utility Work Order is to be submitted for approval before submission of the claim with its supporting data. The date as shown in the heading of the Utility Work Order must be prior to the date work was actually done.

C. Numbering Utility Work Orders

All Utility Work Orders, whether a contract embraces only one project or many projects, are to be numbered in continuous sequence for each project. Once a number is assigned to a Utility Work Order if will retain this number throughout the time of the project even though the work order may have become voided for some reason.

20.07 Salvage

Materials recovered from the utility relocation are to be inspected to prevent junking or scrapping re-usable items and to assure that a proper allowance is made for any salvaged material.

A letter or list showing a breakdown of recovered materials where the materials are located, their relative condition, and the time and place these materials will be sold or available for inspection, is to be prepared and submitted to the Construction Bureau, Helena. The Federal Highway Administration will then be informed of the above information. The letter is necessary to prevent citing the utility company for slavage value of the materials when an audit is performed.

A signed statement is required on the final billing that credit has been allowed for all salvaged material, that items scrapped were available for inspection and proper notice thereof was given.

20.08 Contract Records

A. A diary is to be maintained for recording the notice to proceed date, the date when the Utility Company moved on to the job, the date when work began, the dates when important portions of the work were completed and the date when all work was completed. The type of day by day activities that need recording vary considerably depending upon the type of agreement and whether the work is being done by the Utility Company or a contractor. Therefore, the daily entries should be modified to fit the job conditions but must include any data necessary to establish the basis of payment and verify that any work paid for was actually performed. These entries generally include but are not limited to the following: The number and classification of men working; The hours worked; The material used; The major items of equipment used; The location of work operations by stations and the number of units of work completed; Delays encountered in or caused by utility work; Damages to private property; A record of all materials removed from the job site that are returned to stock or are scrapped. All daily entries should have weather information and be dated by the person making the entries.

B. General records of the work should be kept in the project utility files made expressly for this portion of the highway contract. These files are to contain all data necessary to authorize and describe the proposed work, the detailed information supporting any payments made or due, correspondence, and the completion data including statements of disposition of salvaged materials.

The Consrtruction Bureau, as well as the Utility Section, will need copies of utility work authorizations and notices given to a utility company by the District or Division. This information is needed in the Construction office to help maintain current files on a utility company's job time and movements. Authorization and notices to be submitted are:

1. The authority to proceed with the utility work.
2. Notice of the date utility work started.
3. Notice of when the utility work was completed.

C. A review of the flagging hours and travel time expended by the railroad company's flagmen is needed to be sure the flagging and travel records billed to the State are accurate. Several interviews with the railroad flagmen, during the time flagging is being used, may be necessary. These interviews are especially needed when the contractor changes his work schedule. Visual checks can be made occasionally to verify the verbal information.

The interviews are not needed on a daily basis, so a daily diary entry is not necessary. But information from the interviews is to be entered on the day it is obtained.

SAMPLE FORM FOR LUMP SUM BILLINGS

TO: STATE HIGHWAY COMMISSION OF MONTANA

NAME: MONTANA POWER COMPANY
(Utility Company)

ADDRESS: HELENA, MONTANA

Cost of rearranging facilities because of construction of Highway Project:

Number F-77(15)

Work Order Number 7-12959

Work Started February 5, 1968 Completed March 4, 1968

We hereby submit our bill which covers our agreement with the State of Montana

dated December 22, 1968 which is on a Lump Sum basis.

Net Amount This Claim $707.00

CERTIFICATION

I certify that this claim complies with the State agreement and the Bureau of Public Roads' Policy & Procedure Memorandum 30-4 in that MONTANA POWER COMPANY constructed the most economical type of facilities in the new location that would satisfactorily meet the same service requirements of the old facilities in the old location.

Also, I certify that this claim is correct and just in all respects and that payment or credit has not been received.

Dated March 26, 1968 Signed /s/ Verne W. Brown
By:
Title: Division Superintendent

X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X
(Leave Space for Utility and Commission Approvals)

NOTE: The above form is the correct statement to be used when submitting bills on Lump Sum Agreements of $5,000.00 or less.

Please submit eight (8) copies to State Highway Division that authorized work.

FIG. II-6

SAMPLE FORM FOR PROGRESS BILLINGS

Ref: (PPM 30-3 & 30-4)

TO: STATE HIGHWAY COMMISSION OF MONTANA

NAME: MOUNTAIN STATES TELEPHONE
(Utility Company)

ADDRESS: Salt Lake City, Utah

Supporting Statement to bill for adjustment of facilities required by Construction of Highway Projects.

Progress Billing Number 3

Project Number F 107(10) I.C. F 107(12) Const.

Work Order Number M-8-0506 Work Started December 18, 1967

Period of Progress Billings May, 1968

Labor & Equipment Costs	$ 6,546.00
Materials Costs	$ 16,495.00
Miscellaneous Expense (Including payment to approved Contractors)	$ 22,190.00
Materials Credits	$ (19.00)
Total Claim to Date	$ 45,212.00
Less 10% Retention	4,521.00
Sub-Total	$ 40,691.00
Less Previous Billing	$24,133.00
Total Amount Claimed this Billing	$ 16,558.00

I certify that this claim is correct and just in all respects and that payment or credit has not been received.

July 5, 1968
(Date)

Payee MOUNTAIN STATES TELEPHONE & TEL.COMPANY
(Utility Company)

By J.B. DePlazes
(Designated Company Representative)

X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X
(Leave Space for Utility and Commission Approvals)

NOTE: *Amount claimed cannot exceed 90% of the Agreement. Approved utility work orders are also eligible for 90%.

Submit eight (8) copies to State Highway Division that authorized work.

*State's portion of the agreement and utility Work Order.

FIG.II-6a

CONST. FORM 7
(Revised 2-59)

INTER-DEPARTMENTAL MEMORANDUM

STATE HIGHWAY COMMISSION OF MONTANA

From [redacted], Division Engineer

Date March 11, 1968

To CONSTRUCTION ENGINEER, HELENA

Subject: UTILITY CLAIM

PROJ. NO. F-FG 270(18) I.C.
F-FG 270(19) Const.

UTILITY COMPANY MONTANA-DAKOTA UTILITY COMPANY

ADDRESS Williston, North Dakota

WORK STARTED October 3, 1966

WORK COMPLETED October 18, 1967

AGREEMENT DATE July 27, 1966

AMOUNT $2,000.00 Agr.
$1,181.80 States

CLAIM AMOUNT $1,327.58

(FINAL -- ~~PROGRESS~~)

OVERRUN AMOUNT $145.78

COVERED BY U.W.O. NO. One

REMARKS: 100% credit was given for salvage as all poles removed were in A 1 condi One 60' and one 75' pole were installed temporarily to provide clearance while embankment was being constructed. These were later removed and 50' poles installed on the inslope to shorten the span and provide necessary clearance.

The following is original and new locations of facilities moved:

ORIGINAL LOCATIONS			NEW LOCATIONS		
Station	Distances	Remarks	Station	Distances	Remarks
203+00	83' Rt.	Private R/W Salvage 40' Pole	203+24	81' Rt.	New 75' Pole
			250' E. of above Sta.		New 50' Pole
500' E. of Sta. 203+24		Private R/W Salvage 40' Pole	500' E. of above Sta.		New 50' Pole
205+12	30' Lt.	Private R/W Salvage 40' Pole	205+12	32' Rt.	New 50' Pole
290' W. of above Sta.		Private R/W Salvage 40' Pole	290' W. of above Sta.		New 60' Pole

SUBMIT IN TRIPLICATE TO
CONSTRUCTION DEPARTMENT

/s/ [redacted], Resident Engineer
Avoid Verbal Instructions

FIGURE II-7

CONST. FORM 7
(Revised 2-59)

INTER-DEPARTMENTAL MEMORANDUM

STATE HIGHWAY COMMISSION OF MONTANA

From [redacted], P.E., Division Engineer

Date March 11, 1968

To CONSTRUCTION ENGINEER, HELENA

Subject: UTILITY CLAIM

PROJ. NO. I-IG-15-2(10)125 U-1

UTILITY COMPANY CITY OF BUTTE

ADDRESS City Hall, Butte, Montana

WORK STARTED September 25, 1967

WORK COMPLETED

AGREEMENT DATE March 24, 1967

AMOUNT $22,000.00 Agr.
$18,231.73 State

CLAIM AMOUNT $5,697.55

(~~FINAL~~ -- PROGRESS) No. 3

OVERRUN AMOUNT

COVERED BY U.W.O. NO.

REMARKS: Prog. No. 1, Amt. $5,511.14 submitted November 9, 1967
Prog. No. 2, Amt. $5,854.70 submitted December 19, 1967
Prog. No. 3, Amt. $5,697.55 Total To Date $17,063.39

The following is original and new locations of facilities moved:

ORIGINAL LOCATIONS			NEW LOCATIONS		
Station	Distances	Remarks	Station	Distances	Remarks

Pole data and sketch to accompany final report.

SUBMIT IN TRIPLICATE TO
CONSTRUCTION DEPARTMENT

/s/ [redacted], Resident Engineer
Avoid Verbal Instructions

FIGURE II-8

CONST. FORM 7
(Revised 2-59)

INTER-DEPARTMENTAL MEMORANDUM

STATE HIGHWAY COMMISSION OF MONTANA

From [redacted] P.E., Division Engineer

Date January 31, 1968

To CONSTRUCTION ENGINEER, HELENA

Subject: UTILITY CLAIM

PROJ. NO. F-8(8) U-1

UTILITY COMPANY Great Northern Railway Company

ADDRESS St. Paul 1, Minnesota

WORK STARTED October 2, 1967

WORK COMPLETED October 30 1967

AGREEMENT DATE January 11, 1967 Agr.
January 31, 1967 Det.Est.

AMOUNT $9,600.00 *(2400 hrs.)

CLAIM AMOUNT $545.83

(~~FINAL~~ -- PROGRESS) No. 7

OVERRUN AMOUNT

COVERED BY U.W.O. NO.

REMARKS: NO FACILITIES INVOLVED

*See Proj. Spec. Prov.

Const. Form 7 - F-8(9) U-1, Amt. $252.45 - 74 hrs. - October - Bill

The following is original and new locations of facilities moved:

ORIGINAL LOCATIONS — NEW LOCATIONS

Station Distances Remarks — Station Distances Remarks

Prog. No. 1, Amt. $287.15 - 93 hrs. - April 1967
Prog. No. 2, Amt. $177.81 - 56 hrs. - May 1967
Prog. No. 3, Amt. $ 73.14 - 22 hrs. - June 1967
Prog. No. 4, Amt. $404.12 -125 hrs. - July 1967
Prog. No. 5, Amt. $257.03 - 78 hrs. - August 1967
Prog. No. 6, Amt. $393.92 -112 hrs. - September 1967
Prog. No. 7, Amt. $545.83 -160 hrs. - October 1967
TOTAL TO DATE - $2,139.00 - 646 hrs.

SUBMIT IN TRIPLICATE TO
CONSTRUCTION DEPARTMENT

FIGURE II-9

/s/ [redacted], Resident Engineer
Avoid Verbal Instructions

SAMPLE FORM FOR LUMP SUM BILLINGS

TO: STATE HIGHWAY COMMISSION OF MONTANA

NAME: MONTANA POWER COMPANY
(Utility Company)

ADDRESS: HELENA, MONTANA 59601

Dost of rearranging facilities because of construction of Highway Project:

Number F-77(15) I.C. F-77(16) Const. Townsend - Helena

Work Order Number 7-12959

Work Started February 5, 1968 Completed March 4, 1968

We hereby submit our bill which covers our agreement with the State of Montana dated December 22, 1968 which is on a Lump Sum basis.

Net Amount This Claim $707.00

CERTIFICATION

I certify that this claim complies with the state agreement and the Bureau of Public Roads policy and Procedure Memorandum 30-4 in that MONTANA POWER COMPANY constructed the most economical type of facilities in the new location that would satisfactorily meet the same service requirements of the old facilities in the old location.

Also, I certify that this claim is correct and just in all respects and that payment or credit has not been received.

Dated March 26, 1968 Signed /s/ Verne W. Brown
By:
Title: Division Superintendent

X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X
(Leave Space for Utility and Commission Approvals)

NOTE: The above form is the correct statement to be used when submitting bills on Lump Sum Agreements of $5,000.00 or less.

Please submit eight (8) copies to State Highway Division that authorized work.

Figure II-12

SAMPLE FORM FOR LUMP SUM BILLINGS

TO: MONTANA DEPARTMENT OF HIGHWAYS

NAME: MONTANA POWER COMPANY
(Utility Company)

ADDRESS: HELENA, MONTANA 59601

Cost of rearranging facilities because of construction of Highway Project:

Number F-77(15) I.C. F-77(16) Const. Townsend-Helena

Work Order Number 7-12959

Work Started February 5, 1973 Completed March 4, 1973

We hereby submit our bill which covers our agreement with the State of Montana dated December 22, 1972 which is on a lump sum basis.

Net Amount This Claim $707.00

CERTIFICATION

I certify that this claim complies with the state agreement and the Federal Highway Admin. Policy and Procedure Memorandum 30-4 in that MONTANA POWER COMPANY constructed the most economical type of facilities in the new location that would satisfactorily meet the same service requirements of the old facilities in the old location.

Also, I certify that this claim is correct and just in all respects and that payment or credit has not been received.

Dated March 26, 1973 Signed /s/Verne W. Brown
By:
Title: Division Superintendent

X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X
(Leave Space for Utility and Commission Approvals)

NOTE: The above form is the correct statement to be used when submitting bills on Lump Sum Agreements of $5,000.00 or less.

Please submit eight (8) copies to the Division Construction Section that authorized the work.

Figure II-13

SAMPLE FORM FOR PROGRESS BILLINGS

Ref: (PPM 30-3 & 30-4)

TO: MONTANA DEPARTMENT OF HIGHWAYS

NAME: MOUNTAIN STATES TELEPHONE
(Utility Company)

ADDRESS: Salt Lake City, Utah 84100

Supporting Statement to bill for adjustment of facilities required by Construction of Highway Projects.

Progress Billing Number 3

Project Number F 107(10) I.C. F 107(12) Const. Fromberg - North

Work Order Number M-8-0506 Work Started December 18, 1972

Period of Progress Billings May, 1973

Labor & Equipment Costs	$ 6,546.00
Materials Cost	$ 16,495.00
Miscellaneous Expense (Including Payment to approved contractors)	$ 22,190.00
Materials Credits	$ (19.00)
Total Claim to Date	$ 45,212.00
Less 10% Retention	$ 4,521.00
Sub-Total	$ 40,691.00
Less Previous Billing	$ 24,133.00
Total Amount Claimed this Billing	$ 16,558.00

I certify that this claim is correct and just in all respects and that payment or credit has not been received.

June 1, 1973 Payee Mountain States Telephone & Tel. Co.
(Date) (Utility Company)

By ____________________
(Designated Company Representative)

X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X

NOTE: Amount claimed cannot exceed 90% of the Agreement. Approved utility work orders are also eligible for 90%.

Submit eight (8) copies to the Division Construction Section that authorized the work.

Figure II-14

CONST. FORM 7
(Revised 6-73)

DEPARTMENT OF HIGHWAYS

To CONSTRUCTION ENGINEER, HELENA

From SUPVR. DIVISION CONST. SEC.

Designation KALISPELL-WHITEFISH

Date March 10, 1973

Const. Number F-FG 270 (19) Const.

I.C. Number F-FG 270 (18) I.C.

UTILITY COMPANY MONTANA-DAKOTA UTILITY COMPANY

ADDRESS WILLISTON, NORTH DAKOTA 58801

AGREEMENT DATE July 27, 1972

AMOUNT $2,000.00 Agr.
$1,181.80 States

WORK STARTED October 3, 1972

WORK COMPLETED May 15, 1973

CLAIM AMOUNT $1,327.58

(FINAL - ~~PROGRESS~~)

OVERRUN AMOUNT $ 145.78

COVERED BY U.W.O. NO. One

REMARKS: 100% credit was given for salvage as all poles removed were in A-1 condition. One 60' and one 75' pole were installed temporarily to provide clearance while embankment was being constructed. These were later removed and 50' poles installed on the inslope to shorten the span and provide necessary clearance.

The following is original and new locations of facilities moved:

ORIGINAL LOCATIONS			NEW LOCATIONS		
Station	Distances	Remarks	Station	Distances	Remarks
203 00	83' Rt.	Private R/W Salvage 40' Pole	203 24	81' Rt.	New 75' Pole
			250' E. of Above Station		New 50' Pole
500' E. of Station 203 24		Private R/W Salvage 40' Pole	500' E. of Above Station		New 50' Pole
205 12	30' Lt.	Private R/W Salvage 40' Pole	205 12	32' Rt.	New 75' Pole
290' W. of above Station		Private R/W Salvage 40' Pole	290' W. of Above Station		New 60' Pole

SUBMIT IN TRIPLICATE TO
CONSTRUCTION BUREAU

Project Manager
Signature - Title

Figure II-15

CONST. FORM 7
(Revised 6-73)

DEPARTMENT OF HIGHWAYS

To CONSTRUCTION ENGINEER, HELENA

Date March 11, 1973

From SUPVR. DIVISION CONST. SEC.

Const. Number I IG 15-2 (10)125-U-1

Designation BUTTE-WEST

I.C. Number I IG 15-2 (9)125

UTILITY COMPANY CITY OF BUTTE

ADDRESS City Hall, Butte, Montana 59701

AGREEMENT DATE March 24, 1972

AMOUNT $22,000.00 Agr.
$18,231.73 State

WORK STARTED September 25, 1972

WORK COMPLETED

CLAIM AMOUNT

(~~FINAL~~ - PROGRESS)

OVERRUN AMOUNT

COVERED BY U.W.O. NO.

REMARKS: Prog No. 1, Amt. $5,511.14 submitted November 9, 1972

Prog No. 2, Amt. $5,854.70 submitted December 19, 1972

Prog No. 3, Amt. $5,696.55 Total to Date $17,063.39

The following is original and new locations of facilities moved:

ORIGINAL LOCATIONS			NEW LOCATIONS		
Station	Distances	Remarks	Station	Distances	Remarks

Pole data and sketch to accompany final report

SUBMIT IN TRIPLICATE TO
CONSTRUCTION BUREAU

Signature - Title

Figure II-16

CONST. FORM 7
(Revised 6-73)

DEPARTMENT OF HIGHWAYS

To ~~CONSTRUCTION ENGINEER, HELENA~~

From ~~SUPVR. DIVISION CONST. SEC.~~

Designation W.S.S. - Harlowton

Date January 31, 1973

Const. Number F-8 (8) U-1

I.C. Number

UTILITY COMPANY GREAT NORTHERN RAILWAY COMPANY

ADDRESS St. Paul, 1, Minnesota 55100

AGREEMENT DATE January 11, 1972 Agr.
January 31, 1972 Det. Est.

AMOUNT $9,600.00 *(2400 hrs.)

WORK STARTED April 2, 1972

WORK COMPLETED October 30, 1972

CLAIM AMOUNT $545.83

(~~FINAL~~ - PROGRESS)

OVERRUN AMOUNT

COVERED BY U.W.O. NO.

REMARKS: NO FACILITIES INVOLVED (FLAGGING)

*See Project Special Provision

Construction Form 7-F-8*9) U-1, Amt. $252.45 - 7 hours - October-Bill

The following is original and new locations of facilities moved:

ORIGINAL LOCATIONS			NEW LOCATIONS		
Station	Distances	Remarks	Station	Distances	Remarks

Prog. No. 1, Amt. $287.15 - 93 hours - April 1972
Prog. No. 2, Amt. $177.81 - 56 hours - May 1972
Prog. No. 3, Amt. $ 73.14 - 22 hours - June 1972
Prog, No. 4, Amt. $404.12 -125 hours - July 1972
Prog. No. 5, Amt. $257.03 - 78 hours - Aug. 1972
Prog. No. 6, Amt. $393.92 -112 hours - Sept. 1972
Prog. No. 7, Amt. $545.83 -160 hours - Oct. 1972
TOTAL TO DATE - $2,139.00 -646 hours

# Construction Number Only:
RR Co. flagging in accordance with Project Special Provisions charge to account 9502, Commodity 705

SUBMIT IN TRIPLICATE TO
CONSTRUCTION BUREAU

Project Manager
Signature - Title

Figure II-17

FORM NO. 21—5M 12-64 58145 TRIBUNE

STATE HIGHWAY COMMISSION OF MONTANA

Order for ~~Additional~~ Work ~~and/or Cost Increase~~

~~UTILITIES~~ – RAILROADS – ~~PUBLIC WORKS~~

PROJECT NUMBER	ORDER NUMBER

...., MONTANA, ..., 19..........

TO.., FIELD ENGINEER

Reference is made to that Agreement dated.., entered into between the ...., the owner and the State Highway Commission of Montana. This Agreement describes certain work to be performed, and the cost, in rearrangement of the Owner's facilities as necessitated by construction of this Project. With the agreed upon work currently in progress, it has been determined, due to conditions not previously evident, as herein described, that additional costs will be incurred in order to effect rearrangement of the facilities involved, thus requiring revision of the original estimate. All terms and conditions shall comply with the original Agreement.

DESCRIPTION

NOTE: This is the form to be used when no original agreement has been made. (Delete the words not applicable).

* Strike out as shown, leaving only the appropriate description of the type work. Utilities - Railroad - Public Work

ESTIMATED COST BREAKDOWN	ORIGINAL AGREED COST —
COST INCREASE	
TOTAL TO DATE	

OWNER

____________________ ____________________, 19______

TYPED NAME SIGNATURE TITLE

RECOMMENDED

STATE HIGHWAY COMMISSION OF MONTANA

____________________ DATE __________, 19______
DIV. ENGR.

APPROVED ____________________, 19______
DATE

____________________ DATE __________, 19______
DIST. ENGR.

____
CONSTRUCTION ENGR.

PROJECT NO. ____________________

U.W.O. NO. ____________________

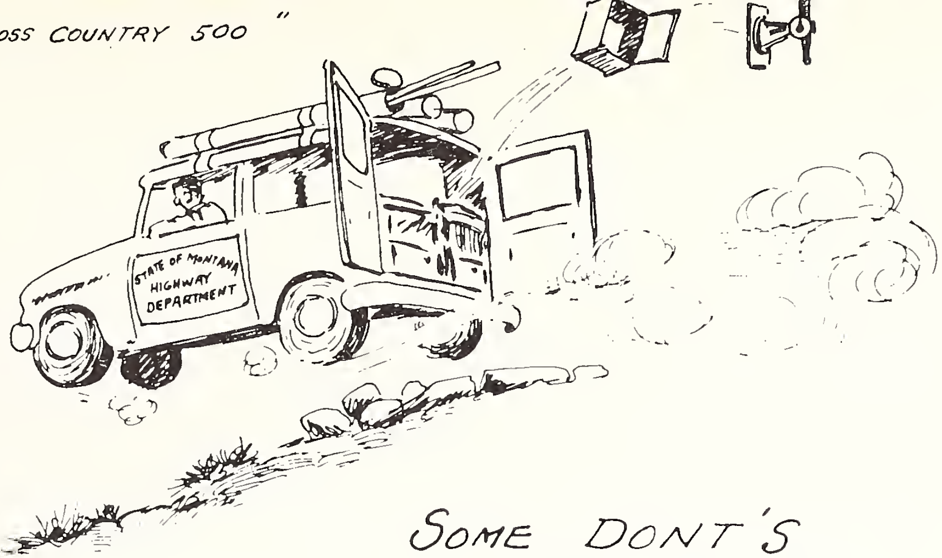
TRANSMI D TO BPR ______

APPROVED BY BPR ______

Figure II-18

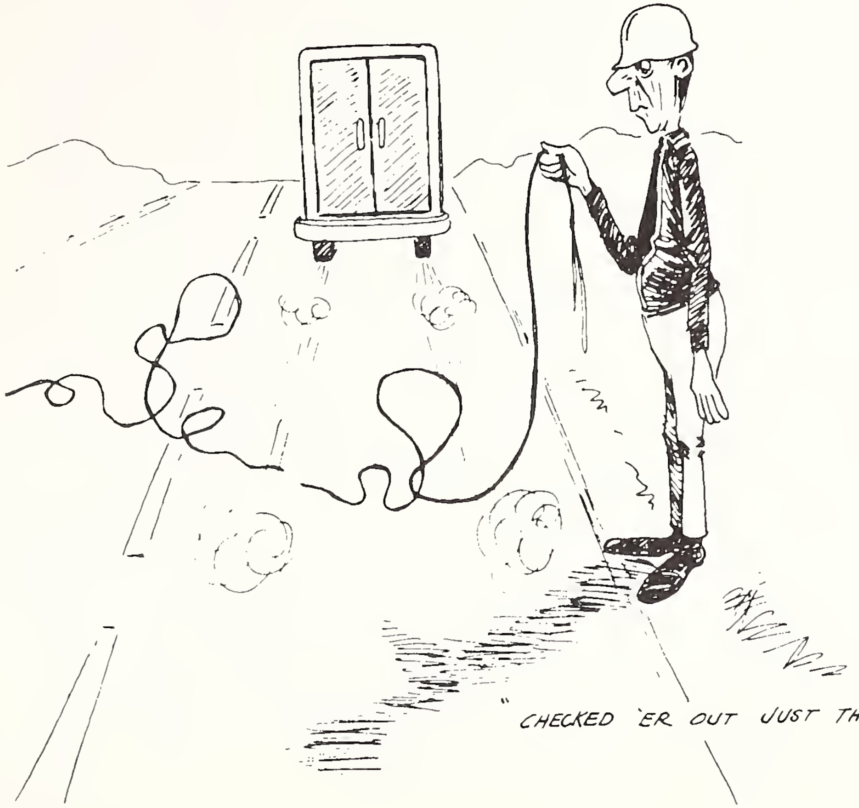
CHAPTER III
CONSTRUCTION SURVEYS

SOME DONT'S IN THE USE OF SURVEY EQUIPMENT !!

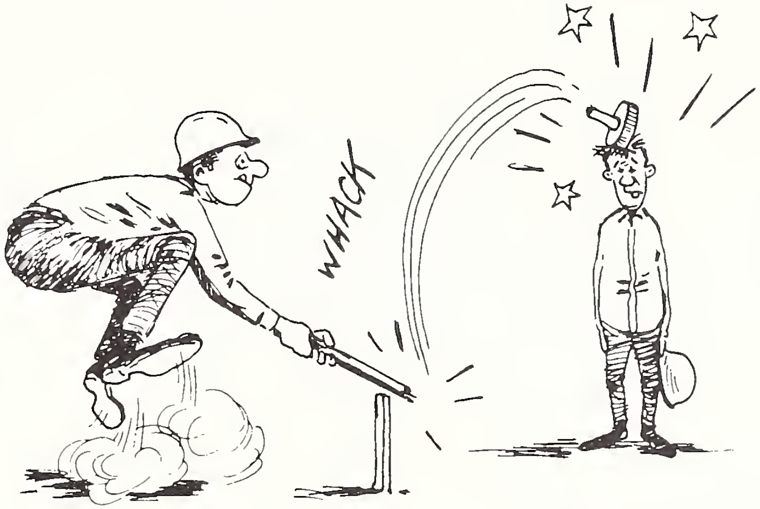


"CROSS COUNTRY 500"

"THE HUNTER"



"CHECKED 'ER OUT JUST THIS MORNING"



"MISSED AGAIN"

CONSTRUCTION MANUAL

CHAPTER III

CONSTRUCTION SURVEYS

III-30 GENERAL

30.00 References
30.01 Conventional Abbreviations
30.02 General
30.03 Safety
30.04 Staking Authorization
30.05 Construction Survey Duties
30.06 Care of Surveying Equipment
30.07 Notes for Electronic Computation
30.08 Precision, Accuracy and Tolerance
30.09 Land and U.S. Survey Monuments
30.10 Survey Notes - General
30.11 Checking Plans
30.12 Cooperation With Contractor

III-31 CONSTRUCTION SURVEYS FOR ROADWAY

31.00 References
31.01 Re-establishing Centerline
31.02 Bench Marks and Leveling
31.03 Staking Right-of-Way
31.04 Clearing and Grubbing Stakes
31.05 Slope Staking
31.06 Staking Borrow Pits
31.07 Finish Grade Stakes

III-32 CONSTRUCTION SURVEYS FOR SMALL DRAINAGE FACILITIES

32.00 References
32.01 General
32.02 Pipe Culverts
32.03 Concrete Box Culverts
32.04 Dikes and Ditch Blocks
32.05 Drop Inlets
32.06 Curb, Gutter and Sidewalks

III-33 CONSTRUCTION SURVEYS FOR MISCELLANEOUS ITEMS

33.00 References
33.01 General
33.02 Fences
33.03 Bin Walls and Retaining Walls
33.04 Traffic Control Devices
33.05 Utilities
33.06 Guard Rail
33.07 Right-of-Way Monuments
33.08 Comfort Stations

CONSTRUCTION MANUAL

CHAPTER III

CONSTRUCTION SURVEYS

III-35 CONSTRUCTION SURVEYS FOR BRIDGES

35.00 References
35.01 Responsibilities for Survey Work
35.02 Preliminary
35.03 Horizontal Control - General
35.04 Horizontal Control - Tangent Dryland Structure
35.05 Horizontal Control - Dryland Structure on Curve
35.06 River Crossing - Triangulation
35.07 General Information - Horizontal Control
35.08 Vertical Control - Bench Marks
35.09 Vertical Control - Construction Grades
35.10 Fill Settlement Check Elevations
35.11 Structure Settlement Check Elevations
35.12 Structures Involving Railroads
35.13 Management of Engineering Control Surveys

III-30 GENERAL

30.00 References

Standard Specifications: Section 5

Safety Manual:

Field and Office Standards

30.01 Conventional Abbreviations

General

B.M.	Bench Mark
B.E.	Bridge End
B.R.	Base of Rail
C/A	Control of Access
C.G.	Curb & Gutter
Conc.	Concrete
Dr.	Drive or Drain
E.B.	Eastbound
Ex.	Existing
Ftg.	Footing
Fr.-Rd.	Frontage Road
G.R.	Guard Rail
Lt.	Left of Centerline
Med.	Median
D.O.H.	Department of Highways
N.B.	Northbound
N.G.	Natural Gas Line
O.C.	On Centers

O.G.---------------- Old Ground

Pvm't--------------- Pavement

Proj.--------------- Projected and Project

P.T.W.-------------- Present Traveled Way

P.L.---------------- Property Line or Plate

Prw. P.------------- Power Pole

Rt.----------------- Right of Centerline

R/W----------------- Right-of-way

R.R.---------------- Railroad or **Railway**

Rd.----------------- Road

Rt.----------------- Route

S.B.---------------- Southbound

Sh.----------------- Shoulder

Stkd.--------------- Staked

Tel. P.------------- Telephone Pole

U.S.G.S.------------ United States Geological Survey

W.B.---------------- West Bound

Curves & Surveys

B.M.---------------- Bench Mark

℄------------------- Centerline

C.S.---------------- Curve to Spiral

D------------------- Degree of Curve

D_c------------------ Degree of circular curve same as spiral curvature at S.C.

Δ ---------------- Delta Angle of Entire Curve

Δ_c ---------------- Intersection Angle between tangents at S.C. and at C.S. or Cent. Angle of circular portion curve.

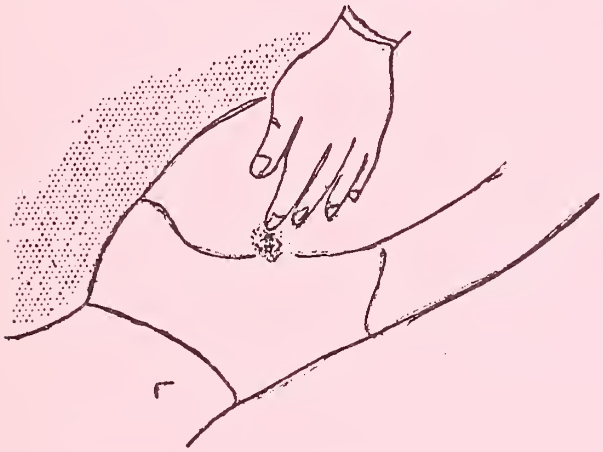
Ext.	External
H.I.	Height of Instrument
H. & T.	Hub and Tack
I.P.	Iron Pin
L_c	Length of Circular Curve
L	Length of Vertical Curve
L_s	Length of Spiral Curve
M.O.	Mid Ordinate
θ	Spiral Angle. Angle of intersection between tangent of complete curve and tangent at S.C. or C.S.
P.C.	Point of Curvature
P.C.C.	Point of Compound Curvature
P.I.	Point of Intersection of Main Tangents
P.O.C.	Point on Curve
P.O.S.T.	Point on Semi-Tangent
P.O.T.	Point on Tangent
P.T.	Point of Tangency
R	Radius
Slp.Stk.	Slope Stake
S.C.	Spiral to Curve; common point of spiral and circular curve
S.T.	Spiral to Tangent
T	Tangent Length of Curve
T.S.	Tangent to Spiral. Common point of tangent and beginning of spiral curve.

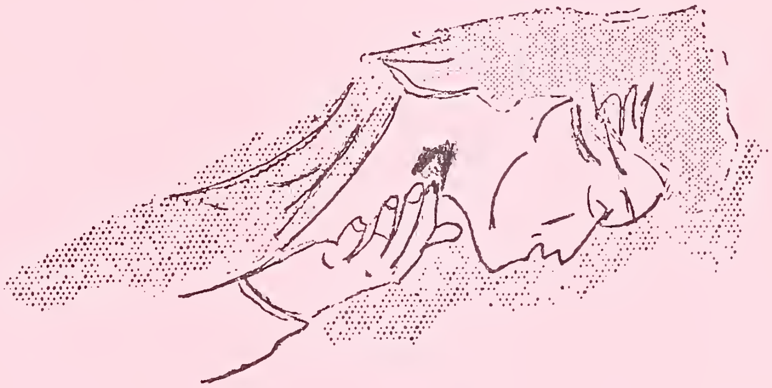
T_s	Tangent Distance P.I. to T.S. or S.T.
T.P.	Turning Point
V.C.	Vertical Curve
V.C. Corr.	Vertical Curve offset correction
AB	Abrupt
C	Cut
D T	Ditch
F	Fill
2:1, etc.	Degree of slope 2' run vs. 1' rise other slopes are expressed in a similar manner 5' run vs. 1' rise, etc.
R P	Reference Point, reference or reference stake
R N	Rounding
⑩	Indicates a survey stake has been offset 10' from its correct location. Marking faces toward true location
$\frac{00}{DL}$	Daylight section. A projection of a ditch gradient (at a specific slope) and its intersection with the natural ground. Usually used to remove an objectionable berm adjacent to a roadway.
$\frac{00}{Sh}$	Indicates groundline at shoulder distance is at template elevation. No cut and no fill. Distance to shoulder from stake is marked below the "Sh."
O H	Overhang
W S	Variable slope or warped slope
V T	Vertical

CARDIOPULMONARY RESUSCITATION

Suppose you are in a crowd, and someone standing near you suddenly falls to the ground and then appears completely motionless. Your ability to help that person if he has had heart stoppage (cardiac arrest) will depend on your alertness in recognizing what has happend and your ability to act smoothly without getting confused. Let us assume that someone else calls for an ambulance and keeps the bystanders in control. If you are the only one trained in CARDIO-PULMONARY RESUSCITATION, here is what you should do.

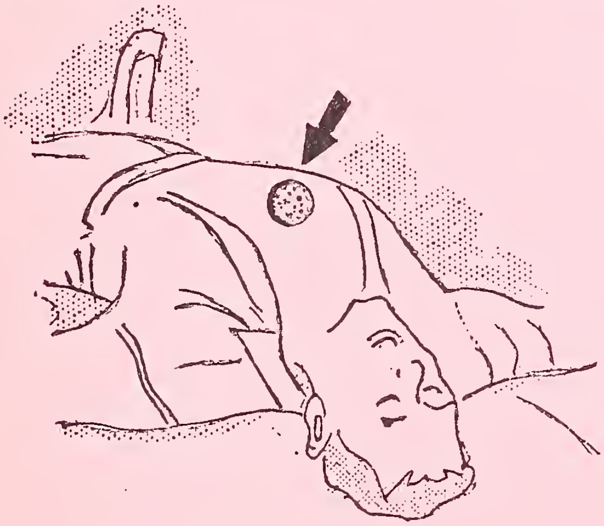
MAKE A DIAGNOSIS OF THE SITUATION





1. CHECK FOR PULSES.

Check the pulse to tell whether or not the heart is beating. Since pulses at the wrist may be very faint, you must check for pulsation of the carotid artery, located on either side of the Adam's apple in the neck. The other place to check for a faint pulse is at the femoral artery in the groin. You must learn how to find these pulses during practice so that you will not be in doubt during an emergency. Feel with the tips of the fingers and not the thumb.



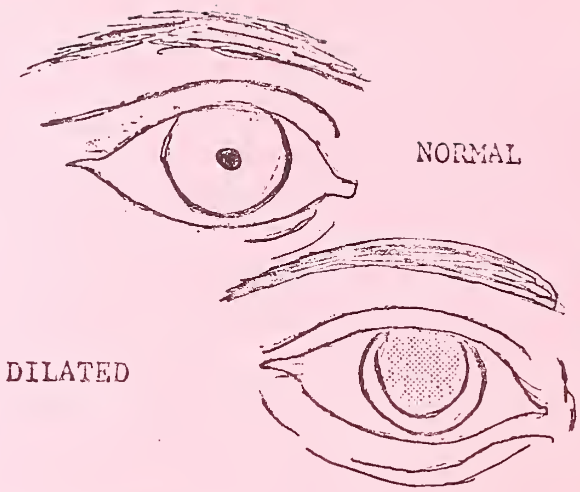
2. CHECK FOR BREATHING.

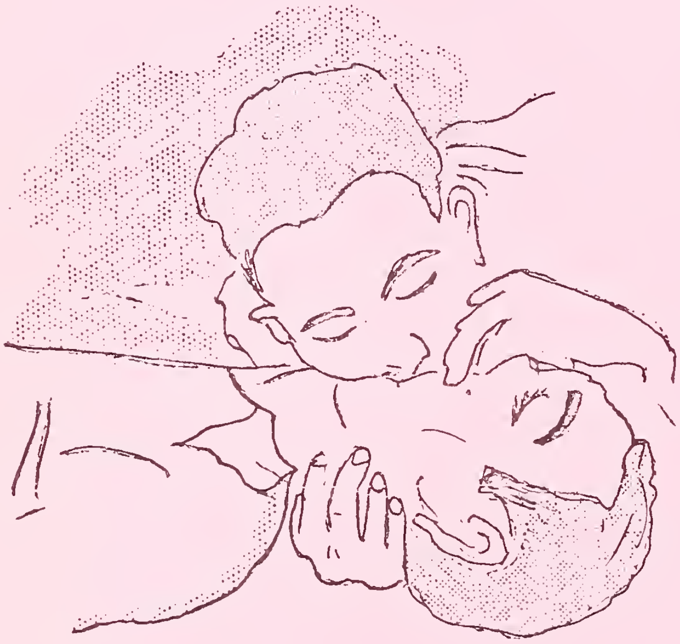
Check for breathing. The place where shallow breathing can be most easily seen is not in the chest, but in the abdomen. The patient should be examined while lying on his back, and the shirt or blouse should be opened enough to see the upper part of the abdomen clearly.

3. CHECK THE PUPILS OF THE EYES.

Look at the pupils. A person whose heart and lungs have stopped working will have widely dilated pupils. That is, the black portion inside the colored part of the eye will be very large, even when light is shining on the eye.

If the patient is without a detectable pulse or breathing, and the pupils of the eyes are dilated, the situation calls for immediate use of heart-lung resuscitation.





4. BEGIN TREATMENT

After checking to find that the air passage is not blocked in the mouth, give four full breaths of mouth-to-mouth or mouth-to-nose respiration. Make sure that the chest rises and falls with each breath.

1. Check the mouth for foreign bodies such as food, a doubled-up tonge, or false teeth.
2. With the patient flat on his back, use one hand to lift up the neck and let his head drop in extension.
3. Pinch the victim's nose closed with the other hand.
4. Take a deep breath and place your mouth over the victim's mouth with airtight contact. For a child your mouth may cover both his mouth and nose. Blow gently with a child.
5. When the victim's chest expands, stop blowing and quickly remove your mouth from his, allowing the air to escape.

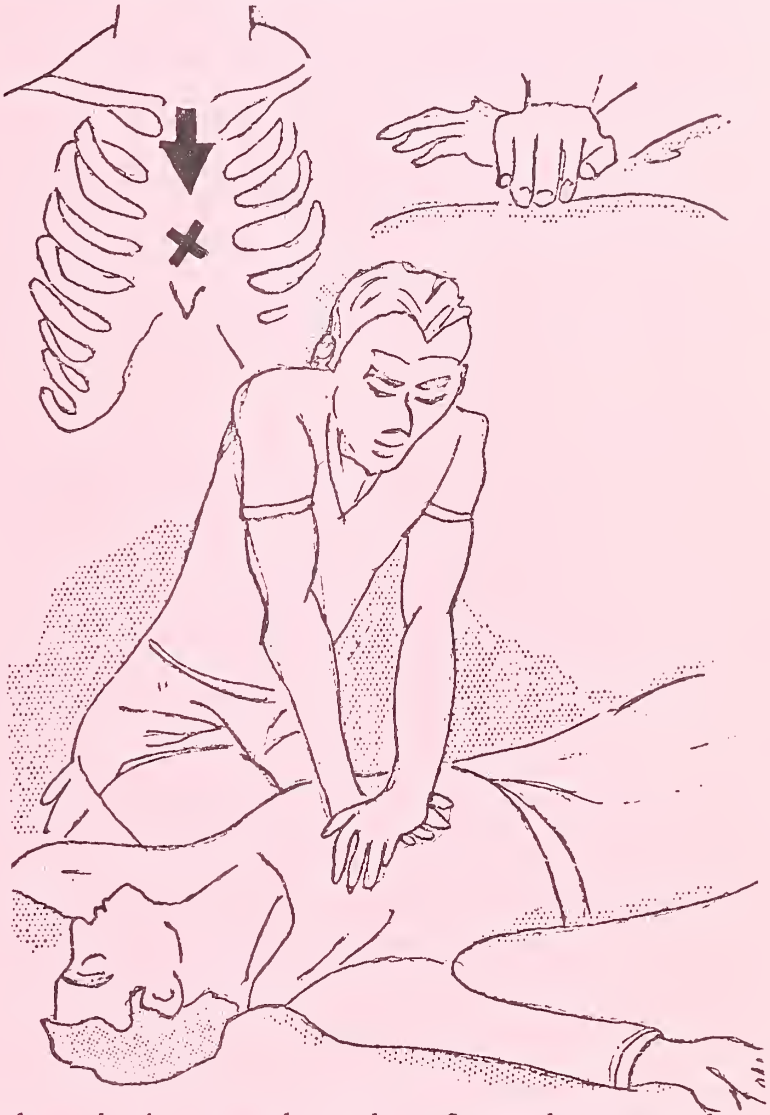
Remember to keep the victim's head tilted far back. In experiments where tests of all methods of artificial respiration were made, the single most important cause of failure was not enough head tilt.

Remember that merely tilting the head back may be enough to start an unconscious person breathing again. It is also possible that the first few breaths of mouth-to-mouth respiration may result in the patient's own heart once again starting to beat. For this reason check for a pulse in the neck before starting external chest compression.

5 CHECK THE PULSE ONCE AGAIN.

6. If no pulse is present now, proceed to give closed chest cardiac compression at the rate of one per second.

1. The patient should be on his back on a firm support, preferably the floor or a table. A soft mattress in a bed or ambulance will not be hard enough unless the mattress is thin and there is a hard surface underneath. Kneel beside the patient and carefully place the heel of one hand on the lower half of the breast bone. Then put your other hand on top of the first. Be careful not to let the hand wander down to the tip of the breast bone or the sides of the chest wall. For children use only one hand. For a baby, only two fingers of one hand are needed.
2. Rock forward and let the weight of your body supply the pressure, not just your hands and arms alone. Bear down so that the breast bone is pushed down approximately one and one half to two inches with each compression. Release the pressure abruptly after each thrust, taking all pressure off the chest.
3. Continue this in rhythm, at the rate of about 60 per minute for an adult, and about 80 times per minute for a child.



7. After fifteen chest compressions, go back and give two breaths of mouth-to-mouth respiration. Return to chest compression and continue 15-and-2 cycle.

8. With every second or third cycle of chest compressions check to see whether or not the pupils have remained dilated, or have become smaller. Also, check from time to time to see if the patient's pulse has come back. This is done by momentarily checking the pulse in the neck while the chest is not being compressed. If the patient's own pulse has returned, this is a sign that his heart is beating and that you may stop doing external cardiac compression. His breathing may also come back, and you may be able to cease mouth-to-mouth respiration. If his respirations are very shallow and the color of the tongue is blue, it is all right to assist his ventilation by giving mouth-to-mouth in time with the patient's own movements with respiration.

Continue your attempts at resuscitation without stopping until the patient is functioning on hiw own, or is in the hands of a physician. Cases are now on record where a patient had to be kept on external cardiac compression and assisted respiration for as long as 55 minutes. Any pause in compression was followed by dilation of his pupils, and no heart action occurred until the patient was treated in a hospital with a defibrillator.

It is possible that with heart-lung resuscitation a patient whose heart is not beating will actually become awake. This only means that enough oxygen is being grought to his brain artificially through the efforts of the rescuers. Any pause will result in a lapse back into unconsciousness because his own heart is not operating. Again, it is possible to restore this person's heart haction with a defibrillator or other medical means and return him to normal life.

SUMMARY

1. Make a diagnosis of the situation.

    A. Check for pulses.

    B. Check for breathing.

    C. Check for the state of the pupils of the eyes.

    If the patient is without a detectable pulse or breathing, and the pupils of the eyes are dilated, the situation calls for immediate use of heart-lung resuscitation.

2. After checking to find that the air passage is not blocked in the mouth, five four full breaths of mouth-to mouth or mouth-to-nose respiration. Make sure that the chest rises and falls with each breath.

3. Check the pulse again.

    If no pulse is present now, proceed to:

4. Locate the proper spot on the chest and give 15 closed chest cardiac compressions at the rate of one per second.

5. Give two breaths of mouth-to-mouth respiration. Return to chest compression and continue the 15-and-2 cycle.

6. Halt long enough to see whether or not the patient's own pulse has returned with every second or third cycle of chest compressions. Look for breathing, and note the state of the pupils.

7. Stop chest compression if the patient's pulse returns. If breathing returns, mouth-to-mouth may be unnecessary. If the patient's heart and lungs do not begin functioning again, continue the technique while bringing the victim to the hospital until he is under the care of a physician.

Drainage

C.B.---------------- Catch Basin
C.A.P.-------------- Corregated Aluminum Pipe
C.S.P.-------------- Corregated Steel Pipe
S.S.P.P.------------ Steel Sectional Plate Pipe
C. & G.------------- Curb and Gutter
Culv.--------------- Culvert
F.L.---------------- Flowline
Hdwl.--------------- Headwall
D.I.---------------- Drop Inlet
H.W.---------------- Highwater or Headwater (infrequent use)
M.H.---------------- Manhole
N.W.El.------------- Normal Water Elevation
R.C.P.-------------- Reinforced Concrete Pipe
S.S.---------------- Sanitary Sewer
S.------------------ Storm Sewer
Vit.---------------- Vitrified
Ws.----------------- Water Service
W.T.---------------- Water Table

30.02 General

The purpose of Chapter III is to suggest procedures, techniques, and note-keeping practices that will promote thoroughness and uniformity in setting construction stakes and performing construction measurements. The general purpose of construction surveys is to perform layout and field control for the work. This includes taking basic measurements necessary for quantity determination, then documenting these various measurements to substantiate the final payment made.

A large proportion of the construction engineering costs, nearly 30%, is consumed in the construction survey therefore, special attention is needed to promote efficiency and economy.

The Division Construction Supervisor is responsible for scheduling surveys, providing the manpower to staff the construction survey teams and quarantee that efficient practice is maintained at all times. However, the Project Manager is directly responsible for the construction survey work. He must have full knowledge of the proper methods to be employed because he is responsible for the results accomplished. The Project Manager and members of his staff are to confer with the contractor's superintendent concerning the method of staking, how stakes are to be marked and guarded, what offsets will be used, etc. The information placed on stakes, abbreviations, locations of messages, if not carefully explained to the contractors men, may result in misunderstanding or misinterpretations and delays.

The specifications provide that the contractor be held responsible for preservation of all stakes and marks. If any of the construction stakes or marks have been carelessly or willfully destroyed by the contractor the cost of replacing them will be charged against him and will be deducted from the payment for the work. Therefore, if it is necessary to replace stakes removed by the contractor's operation, separate notes should be set up stating the date replacement began, personnel and reason for replacing, so the cost of resetting may be properly documented.

A contractor's modern, high production rates make staking a very critical operation requiring detailed planning and intimate cooperation from the contractor so staking should begin as soon as is reasonably possible, and as far in advance of construction as weather and soil conditions will permit. Adequate lead time is essential to prevent delaying the contractor's operation. Staking delays that hinder construction operations will not be tolerated, assuming reasonable notice has been given to the engineer of the contractor's plans and intentions.

Project Managers, instrumentmen, rodmen, and others who are responsible for construction surveying or portions thereof should acquire the tables, handbooks, textbooks, or other data necessary for competent discharge of their engineering and surveying duties.

30.03 Safety

Each employee is responsible for his own safety but should cooperate with other crew members so that safe practices will be in effect at all times. The Project Manager or instrumentman is responsible for safe procedures and should insure that red vests or jackets, warning signs, and hard hats are properly and appropriately used. New crew members or men who seem to be accident-prone should be carefully instructed in the proper use of hand tools, axes, machetes, brush hooks, traffic control, etc.

Transits or levels must frequently be set up in the main stream of rapidly moving traffic. In such cases every reasonable precaution should be made to provide adequate advance warning to the traffic. Use flagmen when necessary. The Department of Highways does not want to lose any surveying instruments but especially, we are concerned about the safety of our personnel on the highways. Any advance warning signs set by survey personnel should be turned away from traffic when they aren't needed, i.e. during lunch breaks, and should be removed at the end of each day when their intended function has been served. Courtesy in dealing with the motoring public will help promote a safer construction surveying atmosphere.

30.04 Staking Authorization

Authorization to begin construction staking prior to contract award, can be obtained from the Construction Bureau. Frequently, the Construction Supervisor wishes to begin staking on complex projects prior to receipt of the staking authorization. On such occasions the Construction Supervisor should draft his request stating the reasons for early staking and submit the request to the Construction Bureau who will in turn obtain the proper charge numbers and submit these back to the Construction Supervisor.

30.05 Construction Survey Duties

The Project Manager is responsible for establishing lines and grades for all vertical and horizontal controls, with State forces. However, the Standard Specifications do provide for the use of contractor's personnel in giving points and lines when unusual circumstances exist. The use of contractor's personnel is done mainly on bridges, or structures. If contractor's men are used, remember that full responsibility for the accuracy of lines, slopes, grades, or other engineering work remains with the State, is under the direction of the Project Manager and must be thoroughly checked.

Construction survey teams are responsible for many different functions, some of the more important of these functions are as shown below:

1. Reproduce and reference centerline.
2. Check, set or re-establish bench levels.
3. Check plans, grades, and calculations; perform grade revisions when necessary.
4. Measure and record clearing and grubbing.

5. Stake culverts and check culvert lengths.

6. Layout and stake structures.

7. Take cross sections and set slope stakes.

8. Layout interchanges, ramps and frontage roads.

9. Set finished grade stakes for sub-grade, base surfacing and finished surfacing.

10. Preserve, perpetuate and witness planned survey monuments.

11. Take remeasure.

12. Record all pertinent survey information in a neat, legible manner. Notes should include date, weather information, survey party personnel and the signature of the crew chief.

13. Provide practical and accurate survey controls in an economical manner. It is important, almost necessary, that the majority of manpower on a survey team is skilled and precise in their duties, but it is also necessary to exchange this information, to communicate knowledge of survey skills to other less-informed men on the crew in order to promote and maintain the degree of morale necessary for efficient surveying. The rodman is truly the spark plug of the team. He can speed the team effort or slow it down. He can be a bottleneck or a highspeed precision human machine to which progress or sluggishness of the entire effort is completely dependent. A rodmans work is easier if crew members mentally check his calculations. It is very important that the various team members exchange their knowledge, help each other, and attempt to know the more important details that control the work. This interchange of knowledge and skills provides opportunity for advancement and provides the Project Manager with a team in which any one of the members can substitute for a member who is not present on any particular day.

The Project Manager has a duty to see that his crew members each have a chance to show their ability in performing such duties as chaining, rodding, "running the gun", keeping notes, and assisting in planning the surveying efforts. When each team member knows the other members work, that member is in a better position to cooperate and can better appreciate the overall needs of the work.

Staking crews are generally composed of from three to five members, but the size should be flexible to insure that other phases of the work can be adequately staffed as the need arises. Crews that are adequately staffed or even slightly understaffed are generally more efficient and experience a higher degree of morale than those which are overstaffed.

30.06 Care of Surveying Equipment

The Project Manager is charged with the full responsibility for care of all equipment assigned for his use. The complexity of his other duties require that he give frequent instruction to his men on the care of all equipment and assign various individuals the responsibility for this equipment. Many methods can be used to serve this accountability, one of which is: One man per vehicle, could be assigned to account for all equipment each day as it is taken from the vehicle, used and then returned to the vehicle. Missing equipment should be searched for by the last man using it. The instrumentman or other individual using a transit or level is in complete charge of that instrument, regarding its care, maintenance and transportation, from the start to the end of each shift. The person using an instrument is, of course, responsible for its protection and proper handling. This responsibility cannot be given to another, regardless of his rank.

The older style levels and transits are gradually being phased out and are being replaced by self-leveling levels and directional instruments or transits with enclosed working parts. The care and maintenance of the older style instruments differs from care and maintenance of the newer style instruments. The same cleaning and repair methods used in the field for one instrument cannot necessarily be adapted to newer instruments. It is, therefore, quite necessary that maintenance manuals be consulted before cleaning, repairing or making adjustments to any of the instruments. Cleaning is to be restricted to the exposed working parts, cleaning is performed with little or no removal of internal mechanisms or mechanisms that would expose internal working parts. Do not remove lenses. This allows dust to enter and may destroy the collimation or line of sight. When cleaning lenses wipe the outside of the lense with a clean, soft linen cloth or a camel's hair brush. Never use alcohol to clean lenses for this will dissolve the cement holding the lenses together.

The new style theodolites and precise transits are to be carried in their cases, not on the tripod over an individual's shoulder. The older style transits and levels may be carried over the shoulder after checking the firmness of threading on the tripod head and gently tightening the upper tangent motion. Leave the lower motion of the transit and the motion of a level unclamped. Clamp the telescope of a transit in line with its centers. Clamping should not be done so tightly that an accidental blow to the instrument will injure it. Don't climb fences with an instrument on you shoulder. Set the instrument over the fence or hand it to another person on the other side of the fence.

Instruments occasionally receive damage either accidentally or through negligence. Send damaged instruments or instruments needing repair and adjustment to the Construction Bureau, Helena, with a transmittal letter identifying the serial number. Explain the type of damage, the repair needs, and write a description of any negligence involved. If damage was caused by the contractor's employees or equipment, the report should reflect this information and the contractor should be advised so the matter may be referred to his insurance company. Repair or replacement costs are often recoverable from contractors or motorists who have struck and damaged these instruments. It will be a great help if the letter of transmittal accompanying damaged instruments has enough explanation and detail for others to become familiar with the incident. This will speed the possible recovery of repair costs from those responsible. Any individual using surveying equipment, especially instruments, must make every effort to prevent their damage. After a damaged instrument is repaired and returned to the field, inspect it and send a memo to the Construction Bureau stating that the instrument has been checked out and repairs made are O.K.. if this is the case.

Every effort will be made by the Construction Bureau to recover from State personnel, contractors or motorists, the cost to repair or replace any damaged instrument, whether the damage be through negligence or accident. This firm policy has been established in an attempt to reduce maintenance costs and reduce overall construction engineering costs, but it does not mean that every accidental damage will result in a rebate from a State employee. The Construction Bureau intends to take a reasonable attitude, but does expect responsibility and pride from field personnel in the care and use of all instruments, implements and equipment assigned to them.

30.07 Notes for Electronic Computation

Many methods are available to accomplish the surveying and staking work. It is the responsibility of the Project Manager, in charge of the construction survey and staking, to be familiar with the current calculation programs which are available and instructions pertaining thereto.

Field notes are made for electronic computation by many individuals who use different methods of forming numbers and figures. The essential requirement is that notes are legible and descriptive enough for the keypunch operators to properly reproduce the information.

Every set of cross section data that is submitted from the field to the Construction Bureau in Helena should be thoroughly and completely edited by the Project Manager, instrumentman, or office man who is responsible for the final accuracy of the notes. Additions or changes are identified by cards placed in the appropriate position in the set of notes and further identified in colored pencil. If changes are of a nature allowing correction by Construction Bureau personnel, or others, the calculations will be completed. If the errors found cannot be corrected in Helena the notes will be returned to the field for corrections or clarification.

A. Cross Section Notes, General

All recommended practices are aimed at electronic computation of earthwork quantities while maintaining the simpliest records possible. The systems and samples conveyed by this manual have been prepared especially for adaption to the electronic computer operations. However, if all 00's and intersections of template and groundline are caught and recorded, areas can still be computed directly from the notes by hand calculator. Therefore, it is essential that all engineers follow the prescribed patterns as clearly and uniformly as possible. Cross-section notes and data are to be entered and recorded on Form CSN-01. An explanatory set of notes is shown on page 30-18B. Page 30-18C is a sample of four-lane highway. These notes concern only ordinary and usual conditions. Succeeding pages and drawings have been prepared to cover and explain some special situations which arise occasionally.

The engineer must decide when and where to take a cross-section. Bear in mind that a recorded cross-section is the basic information for determination of contractual pay quantities and that the contractor and engineer need a certain quantity of stakes, properly located. for construction of the roadway to specified dimensions. Take sufficient cross-sections, at proper locations, to truly reflect the quantities of earth to be moved.

It is common practice to take a cross-section at each 100' station; however, that is not always necessary if other sections taken nearby more truly reflect the ground situation. Sections should be taken at P.C.'s and P.T.'s or at beginning and end of spirals, at all equations, beginning and end of run-off to curves, drainage sites and other pertinent places. Sections should be taken no farther apart than fifty feet on sharp curves and in some cases the maximum should be reduced to twenty-five feet.

It is not always necessary to actually put stakes in the ground at intersections of template and ground. Suppose, for example, that cross-sections are taken every ten or fifteen feet for quantity determination but the contractor only needs stakes each fifty feet. The electronic method of earthwork computation will compute all template-ground intersections between outside catch points. However, it is absolutely necessary that all groundline breaks and template breaks be recorded and that the outside slope catch points be found and recorded. The engineer doing the staking must not deviate, from this basic requirement. See page 30-18G.

All cross-sections should extend completely beyond any work that might be done by the contractor in constructing to the requirements of the plans: groundline readings certainly should extend a reasonable distance beyond the outside grading stake.

Notes should be written with a 3H or 4H pencil, or equal. When the lead is too hard the notes are difficult to read at rapid speed and furthermore do not microfilm well. When the lead is too soft the marks tend to smear.

B. Symbols and Abbreviations

It is customary practice to use symbols and abbreviations as much as is practicable. Past practice indicates a wide variety of symbols being used. The following are to be used as standard.

RN-----Rounding
VT-----Vertical
DL-----Daylight
OH-----Overhang
R------Reference
DT-----Ditch
BK-----Back
AB-----Abrupt
WS-----Warped Slope
AHD or
AH-----Ahead

C. Shrinkage and Swell

Practically all material used in earth work construction will either shrink or swell when taken from its original position and placed in the final position - generally roadway embankment.

Some engineers have been using what are commonly called "standard shrinkage factors". These are reflected in the following tabulation.

Shrinkage Factor	Scope of Double* End Area	*Volume Per Station Before Shrinkage	Shrinkage Factor
1.45	0 to 54	0 to 100	1.45
1.35	55 to 162	101 to 300	1.35
1.35	163 to 378	301 to 700	1.25
1.15	379 to 540	701 to 1000	1.15
1.10	541 to more	1001 to more	1.10

* To obtain the "Embankment +" volume, multiply the "Actual" embankment by the shrinkage factor appropriate for the double area or volume. Note that the volumes are "per station" meaning 100 feet. For other distances between sections the volume must be reduced to an equivalent volume per stations; e.g. two sections are 60 feet apart resulting in a volume of 387 cu. yds. To obtain a "per station" volume multiply the 387 cu. yds. by 100 and then divide by 60 giving 645 cu. yds. per station. From the table above the shrinkage factor would be 1.25.

Rock material will swell when taken from its original position. To obtain the "Embankment +" volume, multiply the "Actual" embankment by the swell factor appropriate for the percentage of rock encountered. You will note that the "Embankment +" volume will be less than the "Actual" embankment when the swell factor is applied.

Estimated Percent Rock	Swell Factor
0-10	1.00
11-25	0.95
26-50	0.90
51-75	0.80
76-90	0.75
91-100	0.70

The shrinkage and swell factors in the tabulation are general or approximate only. Such a tabulation cannot, by any stretch of the imagination, conform to all types of soils and conditions encountered in roadway construction. Some engineers will increase or decrease the factors a certain percentage as their judgment dictates. Judicious selection of such changes, based on experience, can produce very good results in constructing a roadway. The engineer might decide that the factors in the table should be increased 10%, or 20%, due to the type of soils and the location of the embankment.

Other engineers will decide that between Station 0+00 and Station 35+50 the material will shrink 10%, that between Station 35+50 and Station 73+00 it will shrink 20%; that between Station 73+00 and 115+60 it will swell 5%; etc. These shrinkage factors would be applied to all quantities, regardless of size. These determinations would be based on experience with the various types of soils and conditions being encountered.

When earthwork quantities are being determined in the headquarters office by electronic computer, the engineer's recommendations concerning shrinkage and swell must accompany the staking notes.

D. Common Errors

1. General

The compilation of staking notes and their application to the electronic computer has been exceptionally good but, as always happens in a large program involving a great many personnel, a few errors and misunderstandings just naturally occur. This Article deals with those that have occured frequently.

2. + and - Rods

It has been and will continue to be, common practice to assume that, when there is no sign in front of a rod reading, the rod reading is a minus (-); in other words, the reading under consideration is below the height of instrument. It also is common practice to write a plus (+) sign in front of a rod reading denoting ground or template higher than H.I. There have been a few occasions where there were a series of (+) readings and in between were one or two without sign:

Thus $\frac{+5.6}{19}$ $\frac{+4.1}{25}$ $\frac{+3.6}{28}$ $\frac{+2.8}{30}$ $\frac{1.2}{33}$ $\frac{1.4}{35}$ $\frac{+2.3}{38}$ $\frac{+3.2}{41}$ etc.

The persons using the notes don't know whether the readings at 33 and 35 are actually (-) readings or whether the notekeeper forgot the (+) sign. It is suggested that, if they really are (-) readings, they be written thus $\frac{-1.2}{33}$ $\frac{-1.4}{35}$ in such a case.

EXPLANATORY NOTES FOR PLATE NO. VII-05-01

THESE NOTES EXPLAIN THE ENCIRCLED LETTERS, SHOWN IN VARIOUS PLACES ON THE EXEMPLARY CROSS-SECTION NOTES ON PLATE VII-05-01.

-A- ALL ROD READINGS MUST BE WRITTEN TO THE NEAREST 0.1 (TENTH) FOOT, EVEN WHEN THE READING IS AN EXACT FOOT, SUCH AS 9.0. DECIMAL POINTS MUST BE CLEARLY SHOWN. THE ONLY SIGN TO PRECEDE A ROD READING, GENERALLY, IS A '+' SIGN: OTHER READINGS WILL BE UNDERSTOOD TO BE (-) MINUS. (SEE NOTE -T-.)

-B- RECORD DISTANCES TO THE NEAREST FOOT (25) FOR MOST CONDITIONS. THERE WILL BE CASES WHEN IT WILL BE NECESSARY TO RECORD TO THE NEAREST 0.1 (TENTH) FOOT (31.8), SUCH AS SLOPE STAKES, CURBS, IMMOVABLE STRUCTURES, ETC. USE DECIMAL POINTS WHEN SHOWING DISTANCES LESS THAN ONE FOOT (0.7).

-C- THE H.I. (HEIGHT-OF-INSTRUMENT) MUST BE ENTERED IN THIS COLUMN AT ALL TIMES. IT NEED NOT ALWAYS BE AT THE TOP OF THE PAGE. IF A TURN IS RECORDED NEAR THE MIDDLE OF THE PAGE, THE H.I. WOULD OCCUR THERE, BUT IN THIS COLUMN. THE PUNCH CARD OPERATORS COULD MISS IT QUITE EASILY IF IT IS CARRIED ELSEWHERE. WHEN H.I. IS CARRIED FORWARD FROM ONE PAGE TO THE NEXT, ENTER IT AS SHOWN AT C. WHEN A TURN IS MADE, OR B.M. CHECKED INTO, ENTER AS SHOWN AT BOTTOM OF THE COLUMN. THE RECORDER ALWAYS MUST BE CAREFUL TO RECORD H.I. IN SIX FIGURES. A COMMON ERROR IS TO INCORRECTLY COPY THE FIRST TWO FIGURES AND THUS BE OFF A HUNDRED FEET OR MORE. THE OTHER HEADINGS (+, -, ELEV.) APPEAR TO BE SELF-EXPLANATORY.

-D- EACH DAYS WORK SHOULD SHOW THE NAMES OF THE PERSONNEL DOING THE STAKING AND THE TYPE OF WORK EACH PERSON DOES -- SUCH AS INSTRUMENT, ROD, CHAIN, ETC. IF A CHANGE IN PERSONNEL IS MADE DURING THE DAY, IT MIGHT BE DESIRABLE TO MAKE A NOTATION TO THAT EFFECT.

-E- IT IS RECOMMENDED THAT THE "REMARKS" SPACE BE USED AS OCCASION DICTATES. WEATHER CONDITIONS AND TEMPERATURE SHOULD BE NOTED EACH DAY; MORE THAN ONCE, IF NOTED CHANGES OCCUR.

-F- THE PROJECT NUMBER OR IDENTIFICATION SHOULD BE SHOWN FREQUENTLY. THE ENGINEER WOULD NOT BE WRONG IF HE ENTERED IT ON EVERY PAGE.

-G- THE ENGINEER MAY DEVISE HIS OWN SYSTEM OF PAGE NUMBERING. POSITIVE IDENTIFICATION IN PROPER SEQUENCE IS IMPORTANT.

-H- THE DATE SHOULD BE ENTERED, AT THE LEAST, AT THE BEGINNING OF EACH DAYS WORK.

-I- BENCH MARKS AND TURNING POINTS (B.M. & T.P.) SHOULD BE RECORDED AS SHOWN. THE METHOD SHOWN IS USED BY MOST ENGINEERS. A COMPLETE DESCRIPTION MUST BE PROVIDED AS TO TYPE AND LOCATION OF B.M. T.P.'S ARE NOT SO IMPORTANT; MOST ARE TEMPORARY FOR THE ONE TURN; SOMETIMES THEY MAY BE REFERRED TO SEVERAL TIMES. THE TYPE OF USE AND REUSE SHOULD BE CONSIDERED.

-J- THIS COLUMN SHOULD BE USED, AT ALL TIMES, FOR RECORDING STATION NUMBER AND STATION PLUS NUMBER. THIS IS, OF COURSE, QUITE IN KEEPING WITH CUSTOM. THE FIRST ENTRY IN THIS COLUMN, ON ANY PAGE, SHOULD BE COMPLETE AS TO STATION AND PLUS -- E.G. -- WRITE "136+17" -- NOT JUST '+17"

-K- THE FIGURE "43.80" IS PROFILE GRADE REDUCED TO SUBGRADE ELEVATION BY THE SURFACING THICKNESS. SOME ENGINEERS WOULD PREFER TO WRITE "2143.80". THIS INFORMATION SHOULD BE INSERTED IN THIS SPACE AT ALL TIMES.

-L- A FOUR-LANE SPACE, SUCH AS 'L' AND 'M' WILL BE CALLED "QUAD-SPACE" IN FURTHER DISCUSSIONS. THE TEMPLATE RODS (GRADE RODS) AND DISTANCES ALWAYS SHOULD BE WRITTEN INTO THE SAME QUAD-SPACE AS THE STATION AND GRADE. THE TEMPLATE READINGS SHOULD SHOW ALL OF THE BREAKS IN THE COMPLETED ROADWAY SECTION, EXCEPTING THE OUTSIDE CATCH POINTS WHERE TEMPLATE INTERSECTS GROUND.

-M- THE FIRST QUAD-SPACE BELOW THE TEMPLATE NOTATIONS IS TO BE USED FOR GROUNDLINE READINGS. IT ALSO WILL CARRY SLOPE STAKE DATA AND OTHER PERTINENT INFORMATION, SUCH AS ILLUSTRATED. THE LOWER OF THE FOUR SPACES OF THE QUAD-SPACE, WHICH HAS NO VERTICAL LINES, IS TO BE USED FOR NOTATIONS SUCH AS RATE OF SLOPE (5:1 OR 5), REFERENCE (R), END CUT, ETC., ETC. THIS APPLIES TO BOTH TEMPLATE AND GROUND LINE READINGS. IT IS A FREQUENT OCCURRENCE FOR SO MANY GROUND READINGS TO BE RECORDED THAT ALL CANNOT BE ENTERED ON ONE LINE. IN SUCH CASE, PROCEED AS ILLUSTRATED ON THE RIGHT SIDE FOR STATION 15+45. ON THE RIGHT SIDE, THE FIRST LINE SHOULD READ FROM LEFT TO RIGHT, THE SECOND RIGHT TO LEFT, THE THIRD LEFT TO RIGHT, ETC. THE LEFT SIDE OF CENTERLINE WOULD BE THE OPPOSITE.

-N- ALWAYS LEAVE AT LEAST ONE QUAD-SPACE BETWEEN THE LAST QUAD-SPACE USED BY A CROSS-SECTION AND THE FIRST QUAD-SPACE USED BY THE NEXT CROSS-SECTION. DO NOT CROWD THE NOTES.

-O- REFERENCE STAKE OR REFERENCE POINT ENTRIES SHOULD BE SHOWN AS ON PLATE VII-05-01. THERE WILL BE OCCASIONS, SUCH AS A CHANNEL CHANGE NEAR THE OUTSIDE OF THE RIGHT-OF-WAY, WHEN THE ENGINEER WILL WANT THE REFERENCE POINT BETWEEN SUCH A CHANNEL AND THE ROADWAY. HE CAN WRITE "R" UNDER WHICHEVER POINT HE CHOOSES AND RECORD ON OUT TO THE DECIDED LIMIT.

-P- THE ENGINEER FREQUENTLY WILL DESIRE TO ENTER SUCH NOTES AS "END DITCH LEFT", "BEGIN CUT RIGHT", ETC., ETC. SUCH NOTES CAN BE ENTERED AS SHOWN AT STA. 15+80 LEFT SIDE.

-Q- NOTE THAT AT STA. 15+45 THE 00/11.3 WAS FOUND AND RECORDED. THERE ACTUALLY ARE THREE "00'S" AT STA. 15+80 BETWEEN CENTERLINE AND 20 FT. RIGHT; THEY WERE NOT CAUGHT. THE ELECTRONIC COMPUTER WILL INTERPOLATE THEM AUTOMATICALLY. SEE PLATE VII-05-06.

-R- SOME ENGINEERS DESIRE TO INDICATE THE RATE OF FILL SLOPE OR CUT SLOPE UNDER SLOPE STAKE READINGS. SEE STA. 15+00, READINGS AT 22.0 AND 45.4. THE FILL SLOPE OR IN-SLOPE IS 5:1, RECORDED AS 5; THE BACK SLOPE IS 2:1 AND RECORDED AS 2; A DAYLITE SITUATION WOULD USE "DL" BELOW THE READING (00/5.4/35.7/DL). THE RECORDER MAY INDICATE THE RATE OF SLOPE BY EITHER "5" OR "5:1". SUCH ENTRIES ARE NOT NECESSARY TO ELECTRONIC COMPUTATION.

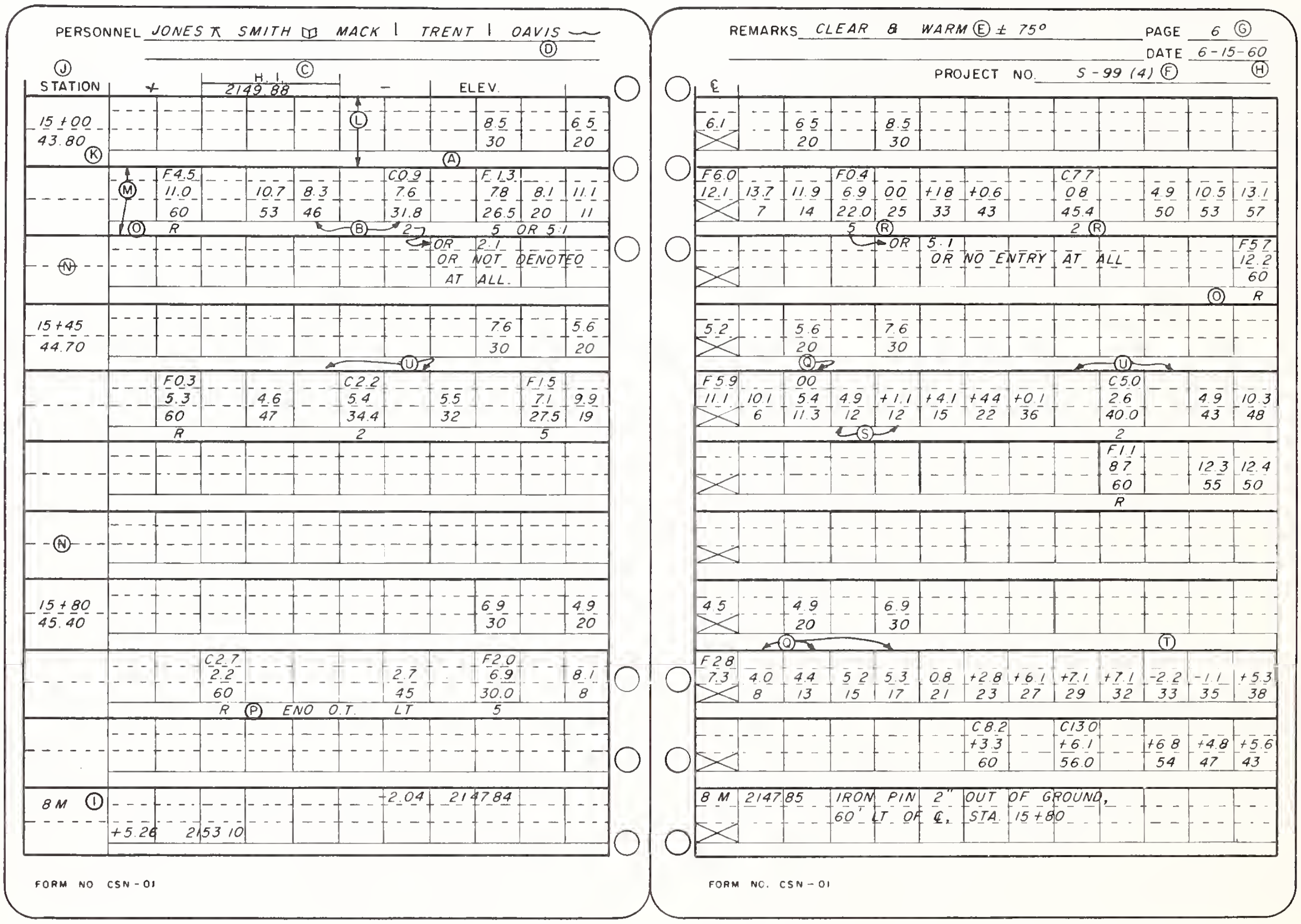
-S- VERTICAL FACES OR SITUATIONS CAN BE ENTERED IN THE NOTES AT THE ACTUAL DISTANCE WITHOUT HAVING TO ADD OR SUBTRACT ANY AMOUNT. THREE, BUT NO MORE, READINGS AT THE SAME DISTANCE CAN BE RECORDED IN EITHER GROUNDLINE OR TEMPLATE OR BOTH.

-T- WHEN THE ENGINEER HAS A SERIES OF PLUS RODS AND IN BETWEEN HAS ONE OR TWO MINUS RODS, IT WOULD BE VERY HELPFUL IF THE MINUS SIGN WERE ENTERED IN FRONT OF THE ROD READING, AS SHOWN AT STA. 15+80 RIGHT. SUCH AN ENTRY CLEARS UP ANY DOUBT THAT MIGHT OCCUR TO THE READER.

-U- AT LEAST ONE BLANK SPACE SHOULD BE LEFT IN THE NOTES ON EACH SIDE OF THE OUTSIDE CATCH SHOT, AS SHOWN FOR STA. 15+45. THIS MAKES IT MUCH EASIER FOR PUNCH CARD OPERATORS TO FIND THE FIRST AND LAST TEMPLATE READINGS.

PLATE NO VII-05-01
DATE MARCH 31, 1964

"SAMPLE CROSS-SECTION NOTES"



PERSONNEL JONES ⊼ SMITH 🕮 MACK | TRENT | OAVIS ~ Ⓓ

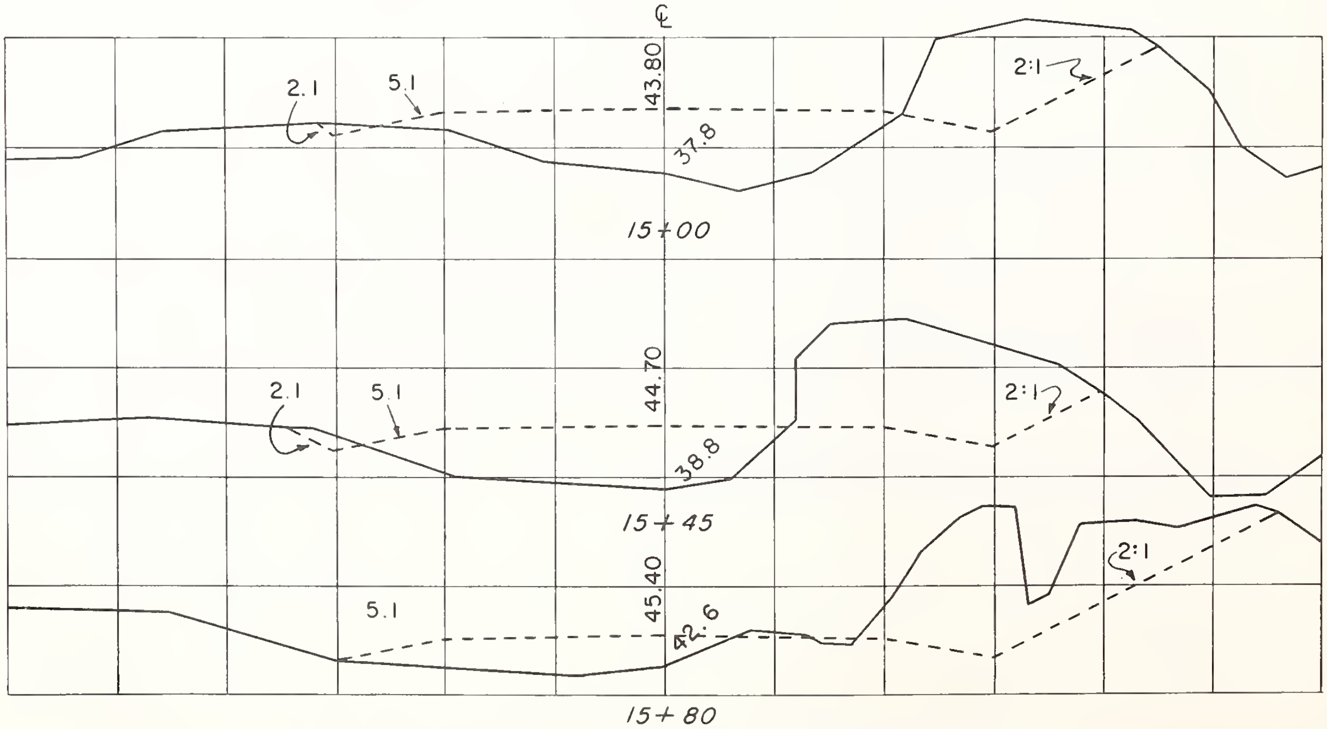
STATION Ⓙ	+		H. I. 2149.88 Ⓒ			−		ELEV.			
15+00 43.80 Ⓚ						Ⓛ			8.5 30		6.5 20
								Ⓐ			
	Ⓜ	F4.5 11.0 60		10.7 53	8.3 46		C0.9 7.6 31.8		F 1.3 7.8 26.5	8.1 20	11.1 11
	Ⓞ	R			Ⓑ		2		5	OR 5:1	
Ⓝ								OR	2:1 OR NOT DENOTED AT ALL.		
15+45 44.70									7.6 30		5.6 20
							Ⓤ				
		F0.3 5.3 60		4.6 47		C2.2 5.4 34.4		5.5 32		F1.5 7.1 27.5	9.9 19
		R				2				5	
Ⓝ											
15+80 45.40									6.9 30		4.9 20
			C2.7 2.2 60				2.7 45		F2.0 6.9 30.0		8.1 8
			R	Ⓟ END	O.T.		LT		5		
8M Ⓘ	+5.26		2153 10				-2.04	2147 84			

FORM NO CSN-01

REMARKS CLEAR & WARM Ⓔ ± 75°
PAGE 6 Ⓖ
DATE 6-15-60 Ⓗ
PROJECT NO. S-99 (4) Ⓕ

℄												
6.1		6.5 20		8.5 30								
F6.0 12.1	13.7 7	11.9 14	F0.4 6.9 22.0	00 25	+1.8 33	+0.6 43		C7.7 0.8 45.4		4.9 50	10.5 53	13.1 57
			5	Ⓡ				2 Ⓡ				
				OR	5:1 OR NO ENTRY AT ALL							F5.7 12.2 60
											Ⓞ	R
5.2		5.6 20		7.6 30								
		Ⓠ							Ⓤ			
F5.9 11.1	10.1 6	00 5.4 11.3	4.9 12	+1.1 12	+4.1 15	+4.4 22	+0.1 36		C5.0 2.6 40.0		4.9 43	10.3 48
			Ⓢ						2			
									F1.1 8.7 60		12.3 55	12.4 50
									R			
4.5		4.9 20		6.9 30								
		Ⓠ								Ⓣ		
F2.8 7.3	4.0 8	4.4 13	5.2 15	5.3 17	0.8 21	+2.8 23	+6.1 27	+7.1 29	+7.1 32	-2.2 33	-1.1 35	+5.3 38
						C8.2 +3.3 60		C13.0 +6.1 56.0		+6.8 54	+4.8 47	+5.6 43
8 M	2147.85		IRON PIN 2" OUT OF GROUND, 60' LT. OF ℄, STA. 15+80									

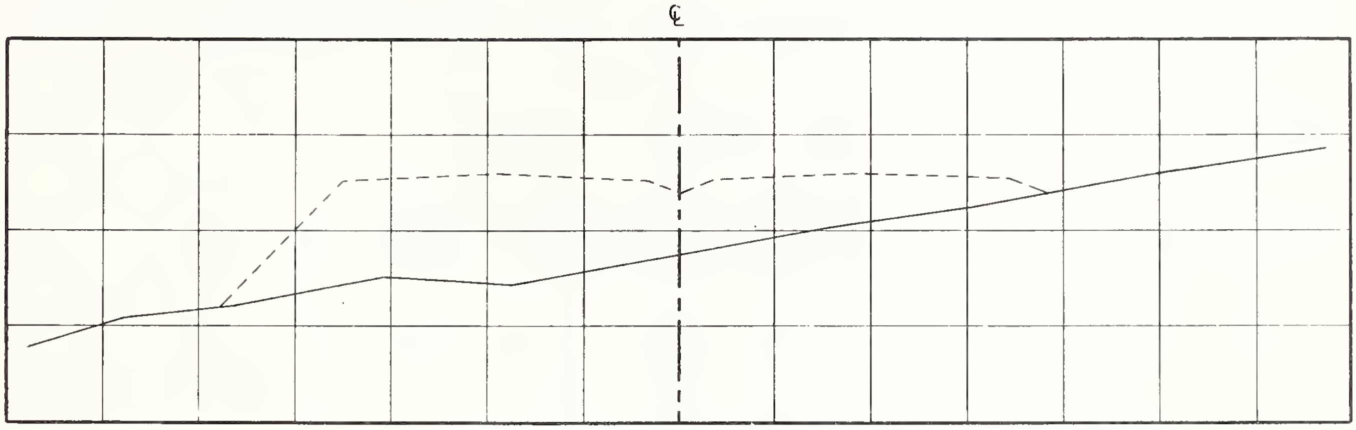
FORM NO. CSN-01

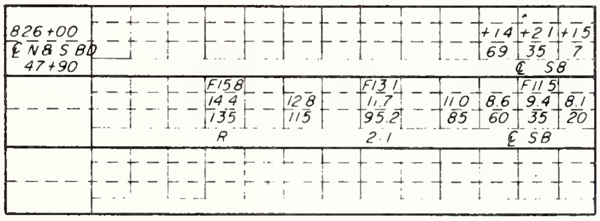


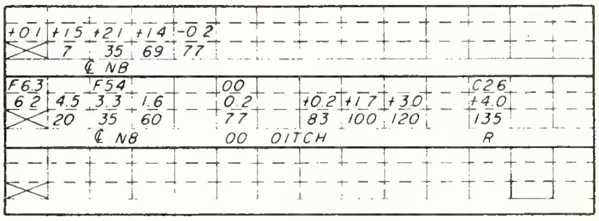
THESE SECTIONS PLOTTED FOR ILLUSTRATION ONLY

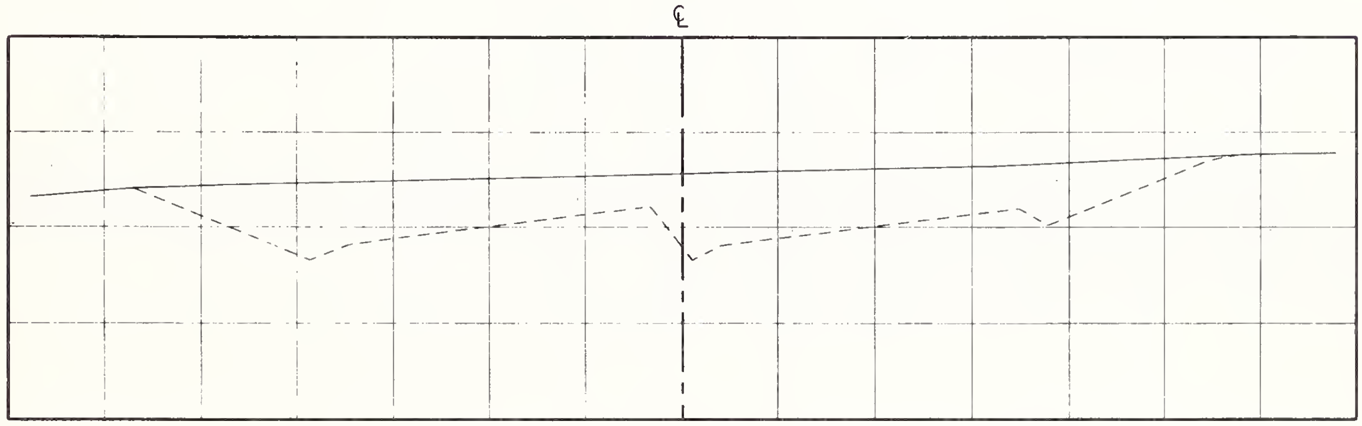
PLATE NO. VII-05-02
DATE MARCH 31, 1964

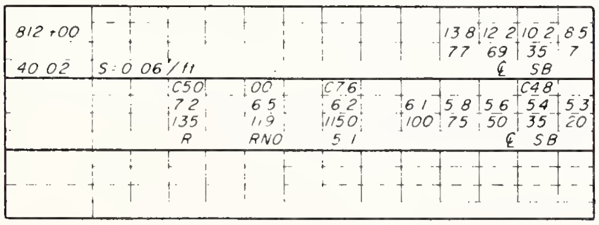
"FOUR-LANE ROADWAY"

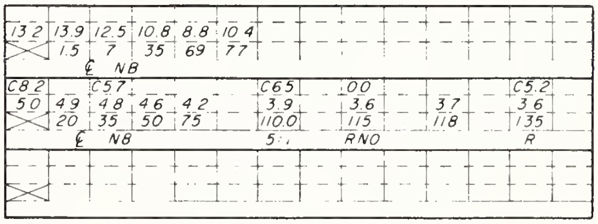



826+00
℄ NB & SB
47+90
+1.4 / 69
+2.1 / 35
+1.5 / 7
℄ SB
F15.8 / 14.4 / 135 / R
12.8 / 115
F13.1 / 11.7 / 95.2 / 2:1
11.0 / 85
8.6 / 60
F11.5 / 9.4 / 35
8.1 / 20
℄ SB


+0.1
+1.5 / 7
+2.1 / 35
+1.4 / 69
-0.2 / 77
℄ NB
F6.3 / 6.2
4.5 / 20
F5.4 / 3.3 / 35
1.6 / 60
℄ NB
00 / 0.2 / 77 / 00
DITCH
+0.2 / 83
+1.7 / 100
+3.0 / 120
C2.6 / +4.0 / 135 / R




812+00
40.02
S:0.06/ft
13.8 / 77
12.2 / 69
10.2 / 35
8.5 / 7
℄ SB
C5.0 / 7.2 / 135 / R
00 / 6.5 / 11.9 / RNO
C7.6 / 6.2 / 115.0 / 5:1
6.1 / 100
5.8 / 75
5.6 / 50
C4.8 / 5.4 / 35
5.3 / 20
℄ SB


13.2
13.9 / 1.5
12.5 / 7
10.8 / 35
8.8 / 69
10.4 / 77
℄ NB
C8.2 / 5.0
4.9 / 20
C5.7 / 4.8 / 35
4.6 / 50
4.2 / 75
℄ NB
C6.5 / 3.9 / 110.0 / 5:1
00 / 3.6 / 115 / RNO
3.7 / 118
C5.2 / 3.6 / 135 / R

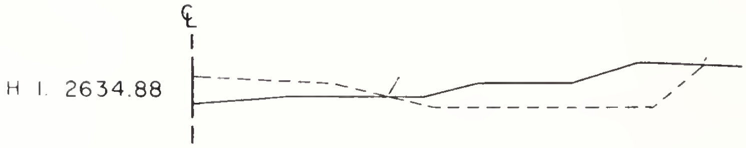
THE TWO SECTIONS ILLUSTRATED ON THIS PLATE SHOW ONE WAY OF STAKING A FOUR-LANE HIGHWAY. THE UPPER SKETCH SHOWS A SECTION ON TANGENT; THE LOWER A SECTION ON A CURVE. THERE ARE SEVERAL METHODS THAT CAN BE AND ARE USED. THIS ONE SEEMS TO WORK OUT QUITE WELL. THESE SKETCHES SHOW HOW THE NOTES SHOULD BE KEPT FOR ELECTRONIC COMPUTATIONS. THEY WILL WORK EQUALLY WELL FOR HAND CALCULATOR COMPUTATION IF ALL 00'S, AS WELL AS ALL SLOPE STAKES, ARE FOUND AND RECORDED.

THE IMPORTANT FEATURE IS THAT ALL ENGINEERS ADOPT AND USE A UNIFORM SYSTEM OF RECORDING NOTES, SUCH AS SET OUT IN THIS SECTION OF THE MANUAL. SEE SECTION 05.03.

IF AND WHEN PARALLEL DITCHES, DIKES, ROADWAYS, ETC., ARE TO BE STAKED ALONG WITH AND AT THE SAME TIME AS THE MAIN ROADWAYS, THE TEMPLATE NOTES, AS WELL AS THE GROUNDLINE NOTES, CAN BE EXTENDED TO INCLUDE THOSE FACILITIES. PLATE VII-05-03 PROVIDES ONE METHOD OF HOW TO PROCEED.

"BORROW WIDENING"

CASE 1

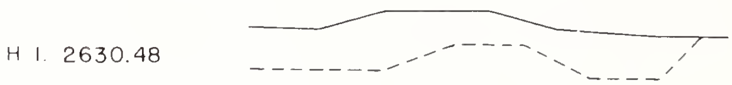


Template $\frac{4.0}{00}$ $\frac{10.0}{20}$ $\frac{13.3}{35}$ $\frac{13.3}{68}$

Ground $\frac{12.7}{00}$ $\frac{12.0}{13}$ $\overset{F1.8}{\frac{11.8}{29.0}}$ $\frac{11.8}{32}$ $\frac{10.0}{42}$ $\frac{10.0}{55}$ $\frac{6.6}{65}$ $\overset{C6.3}{\frac{7.0}{74.3}}$ $\frac{7.5}{80}$

CASE 1. THIS EXAMPLE SHOWS A NORMAL FLAT BOTTOM DITCH SECTION AND THE APPROVED METHOD OF RECORDING GROUND AND TEMPLATE NOTES.

CASE 2.

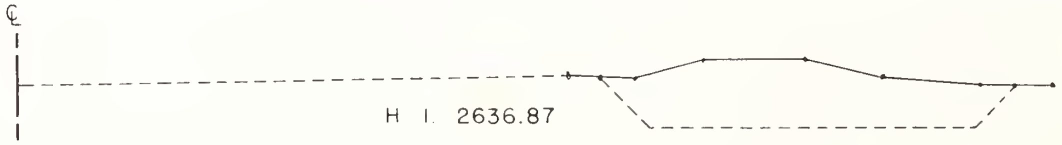


Template $\frac{8.9}{100}$ $\frac{5.5}{110}$ $\frac{5.5}{120}$ $\frac{10.0}{130}$ $\frac{10.0}{140}$

Ground $\frac{3.3}{90}$ $\frac{0.5}{100}$ $\frac{0.5}{115}$ $\frac{3.0}{125}$ $\frac{3.8}{140}$ $\overset{C6.2}{\frac{3.8}{146.2}}$ $\frac{3.8}{150}$

CASE 2. THE ENGINEER FOUND IT NECESSARY TO EXTEND THE CROSS-SECTION NOTES TO WIDEN THE BORROW, AND TO BUILD A BERM AND CHANNEL AFTER STAKING THE SECTION IN CASE 1. THE EXTENSIONS CAN BE STAKED USING THE SAME OR A DIFFERENT H.I., THEN CONTINUING ON TO THE RIGHT AS ILLUSTRATED UNDER CASE 2. SEPARATE NOTES ARE KEPT FOR THE EXTENSIONS BUT THE ENGINEER MUST MAKE THE EXTENSIONS STATION FOR STATION WITH THE ORIGINAL NOTES SO THE QUANTITIES INVOLVED WILL BE CALCULATED AND INCLUDED WITH THE ORIGINAL STAKED QUANTITIES. THE ORIGINAL NOTES MUST BE AMENDED BY DRAWING A RED LINE THROUGH THE C 6.3.

CASE 3.



$\frac{10.0}{00}$ Template $\frac{9.5}{80}$ $\frac{9.6}{86.2}$ $\frac{16.4}{93}$ $\frac{16.4}{140}$

$\frac{10.0}{00}$ Ground $\frac{9.5}{80}$ $\overset{C6.8}{\frac{9.6}{86.2}}$ $\frac{9.7}{90}$ $\frac{6.9}{100}$ $\frac{6.9}{115}$ $\frac{9.4}{125}$ $\frac{10.2}{140}$ $\overset{C6.2}{\frac{10.2}{146.2}}$ $\frac{10.2}{150}$

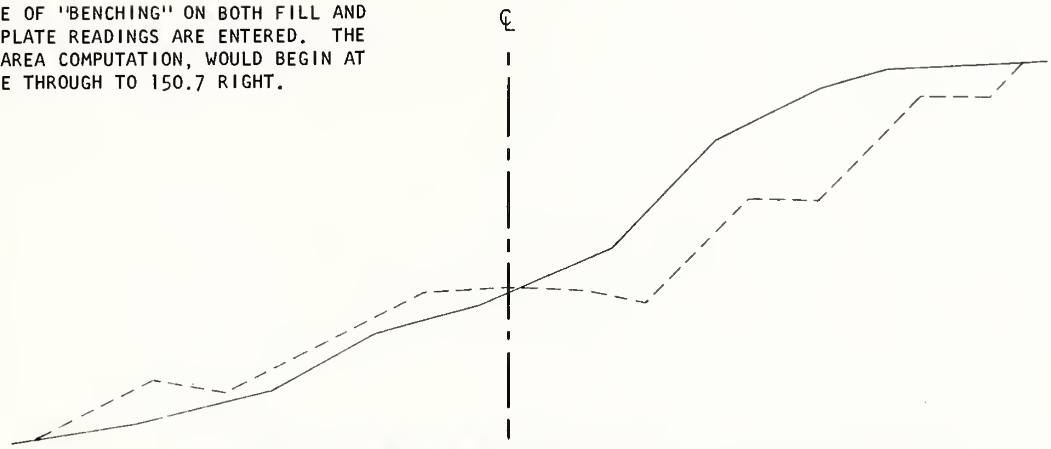
CASE 3. HERE THE ENGINEER DOES NOT WISH TO EXTEND THE ORIGINAL CROSS-SECTIONS, BUT RATHER TIE BACK TO CENTERLINE OR BASELINE BY INSERTING "FAKE" READINGS AT "A" AND REPEATING THE GROUNDLINE READINGS AT 80 AND 86.2 IN THE TEMPLATE READINGS SUCH THAT NO AREA CALCULATIONS WILL BE MADE BETWEEN 00 AND 86.2. THE VOLUMES CALCULATED IN CASE 3 WILL BE SEPARATE FROM THOSE ORIGINALLY STAKED.

THE CROSS-SECTIONS MUST BE TAKEN AT THE SAME SECTIONS AS ON CENTERLINE, IF TO BE MERGED WITH CENTERLINE QUANTITIES.

NO. VII - 05 - 04
MARCH 31, 1964

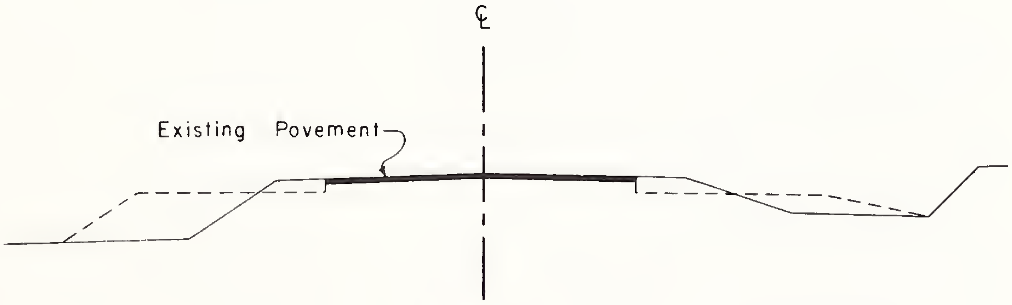
"BENCHING"

THIS IS AN EXAMPLE OF "BENCHING" ON BOTH FILL AND CUT. NOTE HOW THE TEMPLATE READINGS ARE ENTERED. THE TEMPLATE SECTION, FOR AREA COMPUTATION, WOULD BEGIN AT 137.8 LEFT AND CONTINUE THROUGH TO 150.7 RIGHT.



Templote				$\frac{67.6}{105}$	$\frac{70.6}{85}$	$\frac{40.6}{25}$	$\frac{40.0}{X}$	$\frac{40.4}{20}$	$\frac{44.4}{40}$	$\frac{14.4}{70}$	$\frac{14.9}{90}$	+$\frac{15.1}{120}$	+$\frac{14.6}{140}$		
Ground	F 45.0 $\frac{85.0}{145}$ R	F16.4 $\frac{84.0}{137.8}$	$\frac{80.0}{110}$	$\frac{90.0}{70}$	$\frac{54.2}{40}$	$\frac{45.5}{9}$	$\frac{41.6}{X}$	00 $\frac{40.1}{5.0}$	$\frac{28.2}{30}$	+$\frac{2.9}{61}$	+$\frac{17.4}{90}$	+$\frac{23.3}{110}$	C10.7 +$\frac{25.3}{150.7}$	C66.0 +$\frac{26.6}{155}$ R	

"PAVEMENT WIDENING"

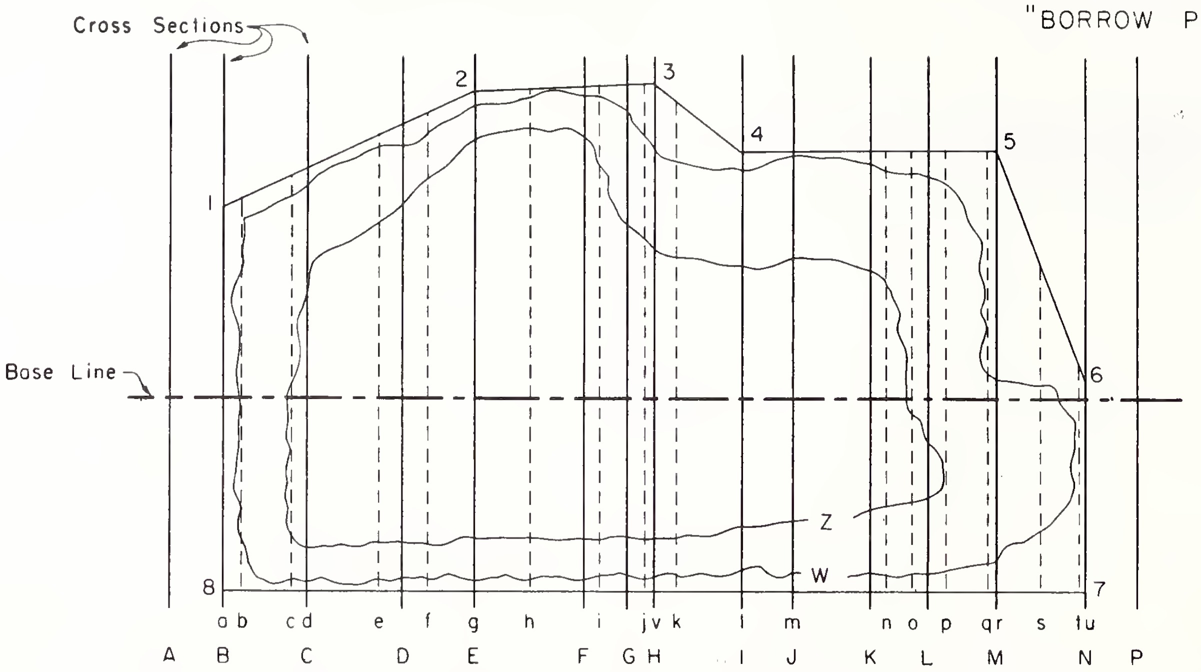


Templote				$\frac{3.5}{9}$	$\frac{2.8}{9}$	$\frac{2.4}{X}$	$\frac{2.7}{9}$	$\frac{3.5}{9}$					
Ground	$\frac{6.6}{28}$ R	$\frac{6.3}{17}$	00 $\frac{36}{13.2}$ DL	$\frac{2.9}{12}$	$\frac{2.8}{9}$	$\frac{2.4}{X}$	$\frac{2.7}{9}$	$\frac{2.8}{12}$	00 $\frac{3.6}{14.7}$ DL	$\frac{4.8}{18}$	$\frac{4.9}{26}$	$\frac{2.0}{29}$	$\frac{2.0}{30}$

THIS ILLUSTRATES WHAT IS PRIMARILY A SURFACING PROJECT OVER WIDENING OF EXISTING PAVEMENT. THE TEMPLATE AND GROUNDLINE READINGS WOULD BE ABOUT AS SHOWN. THE ONLY QUANTITIES TO BE DETERMINED ARE EXCAVATION. THE SHOULDERS WILL BE OBTAINED BY BLUE-TOPS AND THE SLOPES BY MACHINERY

PLATE NO. VII-05-05
DATE MARCH 31, 1964

"BORROW PITS"


Cross Sections
Base Line
1
2
3
4
5
6
7
8
Z
W
a b c d e f g h i j v k l m n o p q r s t u
A B C D E F G H I J K L M N P

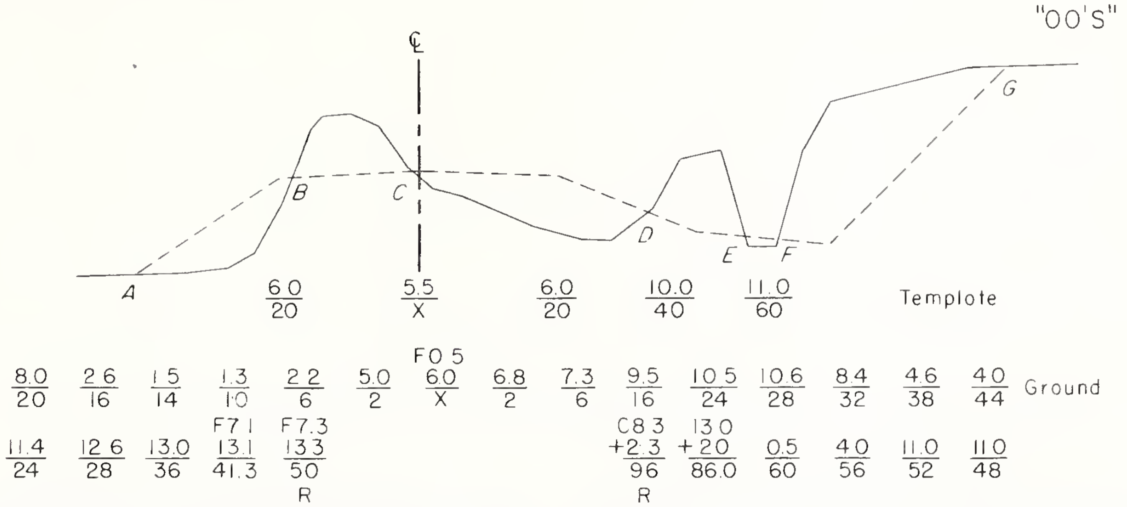
THE MEASUREMENT AND COMPUTATION OF QUANTITIES INVOLVED IN BORROW PITS OR BORROW AREAS CAN BE HANDLED IN VARIOUS MANNERS. THE SAME PROCEDURES CAN BE APPLIED TO STOCKPILES. ONE LINE COMMON TO ALL METHODS IS BASELINE OR CENTERLINE. WHETHER SUCH A LINE TRAVERSES THE APPROXIMATE CENTER OF THE AREA OR IS OFF TO ONE SIDE IS OF MINOR CONSEQUENCE. MOST ENGINEERS PREFER A CENTERLINE OR BASELINE NEAR CENTER. TWO METHODS WILL BE DISCUSSED ON THIS PLATE.

(1) THE ENGINEER ESTIMATES THE BOUNDS OF THE POSSIBLE BORROW AREA, RUNS OUT A CENTERLINE OR BASELINE AS SHOWN ON THE SKETCH, AND DETERMINES THAT CROSS-SECTIONS WILL BE REQUIRED AT VARIOUS PLUSSES DENOTED A, B, C, ETC., N AND P, EACH OF THE LENGTH SHOWN. WHEN THE EXCAVATION IS COMPLETE, HE RETURNS AND RECROSS-SECTIONS ON THE SAME PLUSSES OR LINES AND PROBABLY FINDS IT NECESSARY TO ADD A FEW SECTIONS. HE PROBABLY WOULD VOID THE SECTIONS AT A AND P. HE WOULD, IN THIS CASE, NEED ADDITIONAL SECTIONS AT b, c, e, f, h, i, j, k, n, o, p, q, s and t. HE WOULD HAVE TO INTERPOLATE A GROUNDLINE FOR EACH OF THESE. HE WOULD THEN FIGURE THE END AREA OF EACH SECTION AND FROM THOSE FIGURES DETERMINE THE VOLUME. THIS METHOD HAS BEEN USED FOR MANY YEARS. THE CROSS-SECTIONS HERE WOULD BE THE SAME AS IN ROADWAY CROSS-SECTIONING.

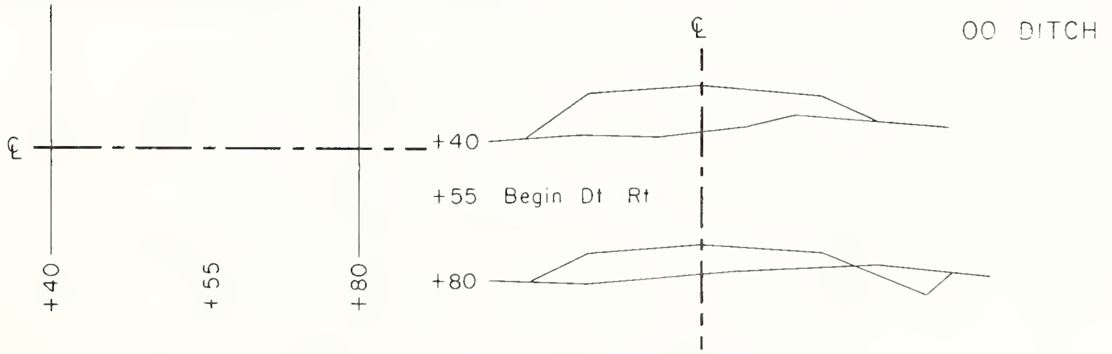
(2) THE ENGINEER ESTIMATES THE BOUNDS OF THE POSSIBLE BORROW AREA, RUNS OUT A CENTERLINE OR BASELINE AS SHOWN ON THE SKETCH, AND DETERMINES THAT CROSS-SECTIONS WILL BE REQUIRED AT VARIOUS PLUSSES DENOTED A, B, C, ETC., N AND P, EACH OF THE LENGTH SHOWN. WHEN THE EXCAVATION IS COMPLETE HE RETURNS AND SIZES UP THE SITUATION. HE NOTES THAT HE WILL NOT HAVE TO REMEASURE TO THE SAME EXTENT HE ORIGINALLY CROSS-SECTIONED BECAUSE THE BOUNDS OF THE PIT ARE LESS THAN HE EXPECTED (REPRESENTED BY LINE W: Z IS THE APPROXIMATE BOTTOM). HE THEN LAYS OUT, ON THE GROUND, THE BOUNDARY LINE "1-2-3-4-5-6-7-8-1". THE BREAKS IN THE BOUNDARY LINE, 2, 3, 4 AND 5, SHOULD BE ON ORIGINAL CROSS-SECTION LINES THAT ARE TO BE REUSED FOR REMEASUREMENT. HE NOTES THAT HE DOES NOT NEED THE PLUSSES AT A AND P. HE NOTES THAT HE WILL NEED CROSS-SECTIONS AT a,b,c,d,e,f,g,h,i,j,v,k,l, m,n,o,p,q,r,s,t, and u TO PROPERLY COMPUTE THE EXCAVATION. HE PROCEEDS TO AMEND THE ORIGINAL GROUNDLINE NOTES BY CROSSING OUT OR CIRCLING THE READINGS BEYOND THE EXTREMITIES OF THE BOUNDARY LINE "1-2-3-4-5-6-7-8-1", AND RECORDING ELEVATIONS WHERE THE LINES C, E, H, I, J AND M INTERSECT THE NEW BOUNDARY LINE; ALSO THE ELEVATIONS AT 1 AND 8 ON LINE B AND 7 AND 6 ON LINE N. THEN HE PROCEEDS TO CROSS-SECTION THE BORROW PIT ON THE LINES NOTED ABOVE, BEING VERY CAREFUL TO TERMINATE EACH SECTION ON THE LINE "1-2-3-4-5-6-7-8-1". HE NOTES A PILE OF WASTED EXCAVATION IN THE CORNER NEAR THE LINE "5-6" WHICH HE ALSO CROSS-SECTIONS ALONG WITH THE EXCAVATION. THE METHOD OF DETERMINATION OF NET QUANTITIES WILL VARY CONSIDERABLY FROM THAT USED IN (1). THIS SYSTEM IS PARTICULARLY ADAPTABLE TO THE ELECTRONIC COMPUTER. A COMPUTER BASE PLANE IS ESTABLISHED A FOOT OR SO ABOVE THE HIGHEST POINT RECORDED IN EITHER ORIGINAL OR REMEASURE NOTES. THEN THE DATA CONCERNING THE ORIGINAL GROUNDLINE IS PROCESSED AND THE VOLUME OF AIR BETWEEN THE BASE PLANE AND ORIGINAL GROUND (LIMITED BY THE LINES "1-2-3-4-5-6-7-8-1") DETERMINED. NEXT, THE REMEASURE DATA IS PROCESSED AND THE VOLUME OF AIR DETERMINED BETWEEN THE BASE PLANE AND THE REMEASURED GROUND (AGAIN LIMITED BY THE LINE "1-2-3-4-5-6-7-8-1"). THE DIFFERENCE IN VOLUMES IS THE NET AMOUNT OF EXCAVATION. THE PILE OF WASTE WILL BE COMPUTED AND DISCOUNTED BUT THE VOLUME WILL NOT BE DISCERNIBLE.

IF THE CONTRACTOR WERE TO EXPAND TO A LARGER AREA THAN ORIGINALLY CONTEMPLATED, THEN THE GROUNDLINE NOTES SHOULD BE EXTENDED ACCORDINGLY. THE FINAL PROCEDURE WOULD BE AS OUTLINED ABOVE.

PLATE NO VII-05-06
DATE MARCH 31, 1964

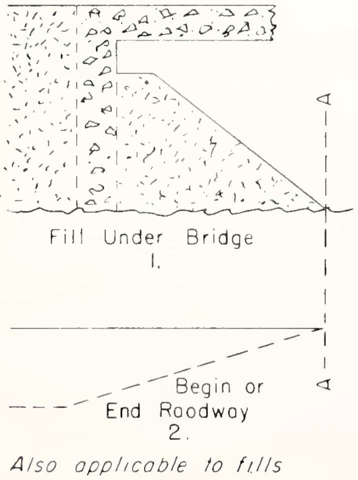


THIS DIAGRAM SHOWS HOW SOME STAKING TIME CAN BE SAVED IF THE ENGINEER IS AUTHORIZED TO TAKE SUCH A SHORT-CUT. IT IS AN ACCEPTED CONTENTION THAT ALL GROUNDLINE BREAKS MUST BE PROPERLY CONSIDERED AND RECORDED IF PROPER QUANTITIES ARE TO BE OBTAINED. THE DIAGRAM SHOWS SEVERAL INTERSECTIONS OF TEMPLATE AND GROUNDLINE. THE RODMAN, UNLESS HIGHLY EXPERIENCED, COULD SPEND CONSIDERABLE TIME IN FINDING THE INTERSECTIONS AT 'B', 'C', 'D', 'E' AND 'F'. WHEN THERE ARE FREQUENT SECTIONS INVOLVED, THE TOTAL TIME CONSUMED IN A DAY WOULD BE QUITE CONSIDERABLE. THE GROUNDLINE SHOWN, OF COURSE, REFLECTS MORE READINGS THAN MOST FOR A NARROW WIDTH. IF THE ENGINEER WERE TO RECORD ALL OF THE BREAKS NECESSARY IN THE GROUNDLINE, ALL OF THE BREAKS IN TEMPLATE, AND THE TWO INTERSECTION POINTS AT 'A' AND 'G', THE ELECTRONIC COMPUTER WOULD FIND ALL OF THE OTHERS DURING THE PROCESS OF AREA DETERMINATION. IT WOULD BE QUITE LIKELY THAT THE ENGINEER WOULD NOT KNOW OF THE TWO "OO'S" AT 'E' AND 'F'. IT IS ABSOLUTELY NECESSARY THAT THE TWO OUTSIDE CATCHS, 'A' & 'G', BE FOUND AND RECORDED IN THE FIELD BECAUSE THESE ARE TEMPLATE DATA AS WELL AS GROUNDLINE DATA. THE COMPUTER WILL MAKE THE ENTIRE AREA DETERMINATION IN ABOUT 15 SECONDS. THE ENGINEER IS CAUTIONED, HOWEVER, THAT IN FOLLOWING THE PRACTICE COVERED ABOVE, HE MUST NOT GET 'SLOPPY' AND MUST PUT IN ENOUGH STAKES ALONG THE ROADWAY TO COVER THE REQUIREMENTS OF GOOD CONSTRUCTION. THIS WOULD BE A VERY ADVANTAGEOUS PROCEDURE WHEN CROSS-SECTIONS ARE CLOSELY SPACED.



THE ABOVE SKETCHES ILLUSTRATE A TYPICAL SITUATION. THESE SKETCHES INDICATE "BEGIN DITCH RIGHT"; THE CONDITION COULD BE "END DITCH RIGHT OR LEFT" OR "BEGIN DITCH LEFT". LET IT BE SUPPOSED, IN THIS CASE, THAT THE DITCH WOULD ACTUALLY BEGIN AT +55 ON THE RIGHT. IT IS NOT NECESSARY TO TAKE A CROSS-SECTION AT +55 AS FAR AS GROUND BREAKS ARE CONCERNED. AN ENTRY IN THE NOTES "BEGIN DT RT +55" WILL SUFFICE. SEE ARTICLE 05.02 AND PLATE VII-05-01. DO NOT USE SUCH A NOTE WHEN A CROSS-SECTION IS TAKEN.

'OO' SECTION



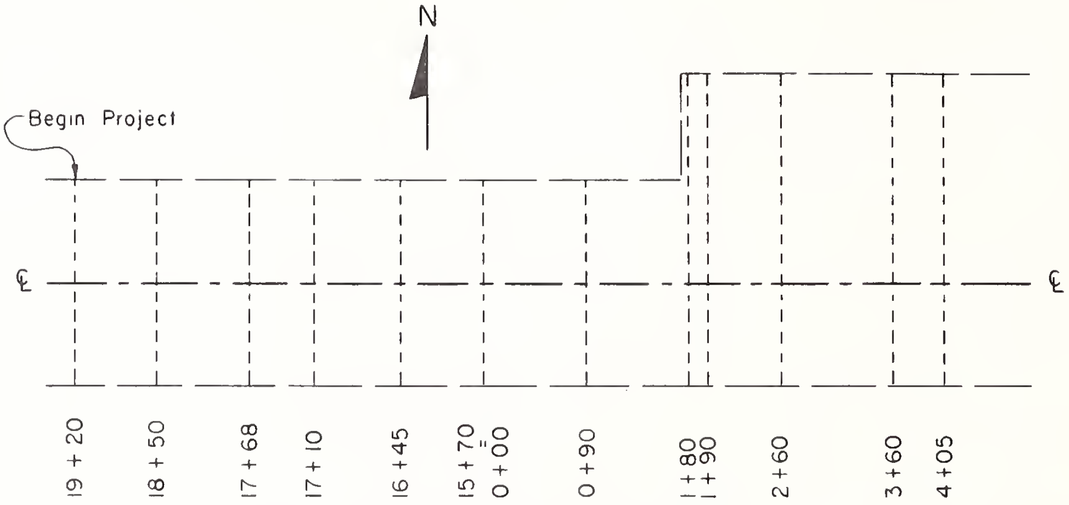
(B) THERE ARE OCCASIONS WHEN IT IS NECESSARY TO SHOW THE END OF A FILL OR END OF A CUT WHERE THE END AREA WILL BE ZERO. TWO EXAMPLES ARE SHOWN AT THE LEFT. THE ROD READINGS IN BOTH CASES CAN BE EITHER ACTUAL OR FICTICIOUS--PROBABLY FICTICIOUS UNDER THE BRIDGE. THE STATIONING SHOULD BE ACTUAL. THE DISTANCE FROM CENTERLINE NEED BE NO CLOSER THAN APPROXIMATE--WITHIN 5 FEET IS CLOSE ENOUGH. THE READINGS ON STATION A ARE SHOWN BELOW.

Case 1.	Template	$\frac{5.6}{19}$	$\frac{4.9}{00}$	$\frac{4.7}{19}$
	Groundline	$\frac{5.6}{19}$	$\frac{4.9}{00}$	$\frac{4.7}{19}$
Case 2.	Template	$\frac{3.2}{25}$	$\frac{3.2}{00}$	$\frac{3.2}{25}$
	Groundline	$\frac{3.2}{25}$	$\frac{3.2}{00}$	$\frac{3.2}{25}$

Preceding sections should be taken as conditions require.

PLATE NO. VII - 05 - 08
DATE MARCH 31, 1964

"MISCELLANEOUS PROBLEMS"



THIS SKETCH IS PREPARED TO REPRESENT SEVERAL SITUATIONS COMMONLY ENCOUNTERED.

1. THE PROJECT BEGINS ON A SURVEY WHICH IS STATIONED FROM EAST TO WEST. THE BEGINNING OF THE STATIONING IS 15+70 WHICH IS EQUAL TO 0+00 ON A SURVEY PROCEEDING FROM WEST TO EAST. CROSS-SECTIONING SHOULD BEGIN AT 19+20 AND RUN EASTWARD THROUGH 18+50, 17+68, 17+10, 16+45, 15+70, 0+00, 0+90, 1+80, ETC., ETC. THEN WHEN THE QUANTITIES ARE WORKED UP THE MASS WILL DEVELOP PROPERLY. THE SAME PROCEDURE WOULD HOLD IF THE STATIONS FROM 19+20 to 15+70 WERE MINUS DISTANCES FROM 0+00, LIKE -3+50, -2+80, -2+08, -1+40, -0+75.

2. THE SURFACING THICKNESS CHANGES 0.8 FT. AT STA. 17+10. THE NOTES WOULD BE RECORDED SOMETHING LIKE THIS:-

H I. 2334.97												
17 + 10 29.00				$\frac{6.4}{20}$		$\frac{6.0}{X}$		$\frac{6.4}{20}$	$\frac{9.4}{35}$			
	F5.2 $\frac{11.2}{50}$ R	$\frac{11.2}{33}$	F3.9 $\frac{10.3}{25.9}$	$\frac{9.3}{18}$	$\frac{7.3}{6}$	F1.2 $\frac{7.2}{X}$	$\frac{6.9}{7}$	00 $\frac{6.2}{10}$	$\frac{3.3}{22}$	C6.0 $\frac{3.4}{47.0}$	C2.6 $\frac{3.4}{50}$ R	
				$\frac{7.2}{21.2}$		$\frac{6.8}{X}$		$\frac{7.2}{21.2}$	$\frac{9.4}{35}$			
17 + 10 28.02	$\frac{11.2}{50}$	$\frac{11.2}{33}$	F3.1 $\frac{10.3}{25.9}$	$\frac{9.3}{18}$	$\frac{7.3}{6}$	F0.4 $\frac{7.2}{X}$	00 $\frac{6.9}{5}$	$\frac{6.9}{7}$	$\frac{6.2}{10}$	$\frac{3.3}{22}$	C6.0 $\frac{3.4}{47.0}$	$\frac{3.4}{50}$

NOTE THAT THE SAME STATION NUMBER IS USED FOR BOTH SECTIONS.
THE COMPUTER WILL SUBTRACT THE STATION NUMBER, GET A DISTANCE
OF ZERO AND THUS THERE WILL BE NO VOLUME.

3. THE DITCH SECTION IS WIDENED ABRUPTLY AT STATION 1+80--1+90. THE NOTES WOULD BE RECORDED SOMETHING LIKE THIS:

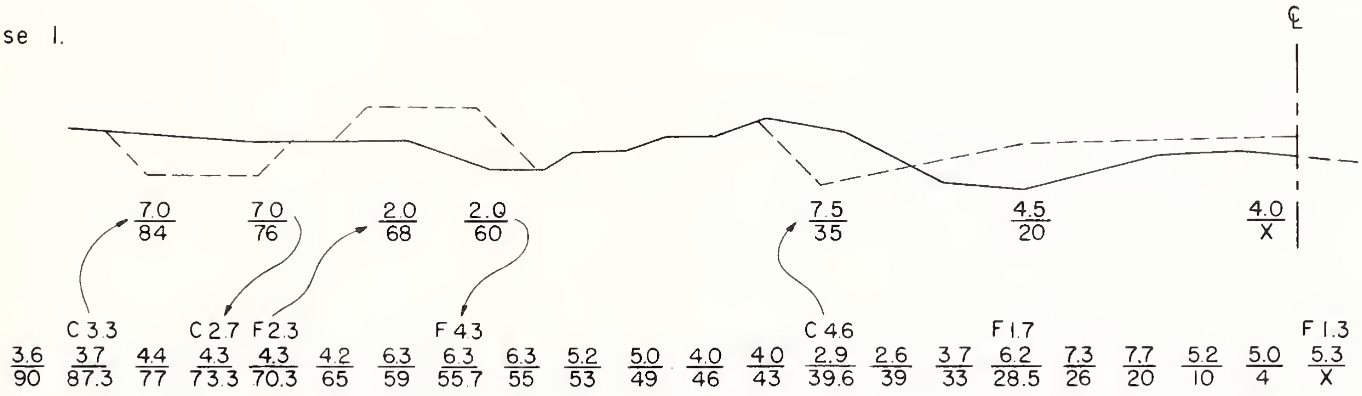
H I. 2630.00										
1 + 80 26.00				$\frac{8.4}{40}$	$\frac{4.4}{20}$	$\frac{4.0}{X}$	$\frac{4.4}{20}$			
	C1.1 $\frac{2.9}{100}$ R	$\frac{3.6}{70}$	C2.8 $\frac{5.6}{45.6}$	$\frac{6.0}{42}$	F1.4 $\frac{5.8}{27.0}$	F1.6 $\frac{5.6}{X}$	$\frac{6.5}{14}$	$\frac{8.6}{24}$	F4.2 $\frac{8.6}{26.3}$	F4.7 $\frac{8.7}{50}$ R
1 + 90 26.00				$\frac{8.4}{85}$	$\frac{4.4}{20}$	$\frac{4.0}{X}$	$\frac{4.4}{20}$			
	C1.1 $\frac{2.9}{100}$ R	C5.5 $\frac{2.9}{96.0}$	$\frac{3.6}{70}$	$\frac{6.0}{42}$	F1.4 $\frac{5.8}{270}$	F1.6 $\frac{5.6}{X}$	$\frac{6.5}{14}$	F4.2 $\frac{8.6}{26.3}$	$\frac{8.7}{50}$ R	

IN THIS CASE, THE END SLOPE, BETWEEN 1+80 AND 1+90, GOES DOWN ABOUT 5 FEET IN 10 OR CLOSE TO 2:1, BETWEEN 45' LEFT AND 85' LEFT.

THERE ARE NO BREAKS IN GROUNDLINE ON THE RIGHT BETWEEN STA. 2+60 and 4+05 SO THE ENGINEER DECIDES TO SHOW ONLY THE DITCH ON THE LEFT. THEREFORE, NO READINGS RIGHT OF CENTERLINE ARE RECORDED. THIS IS WRONG. THE NOTES MUST SHOW A COMPLETE SECTION IN A CASE LIKE THIS---OTHERWISE THE FILL QUANTITY WOULD BE INCORRECT OR CONSIDERABLY LESS THAN IT SHOULD BE.

ROADWAY-CHANNEL CHANGE

Case 1.

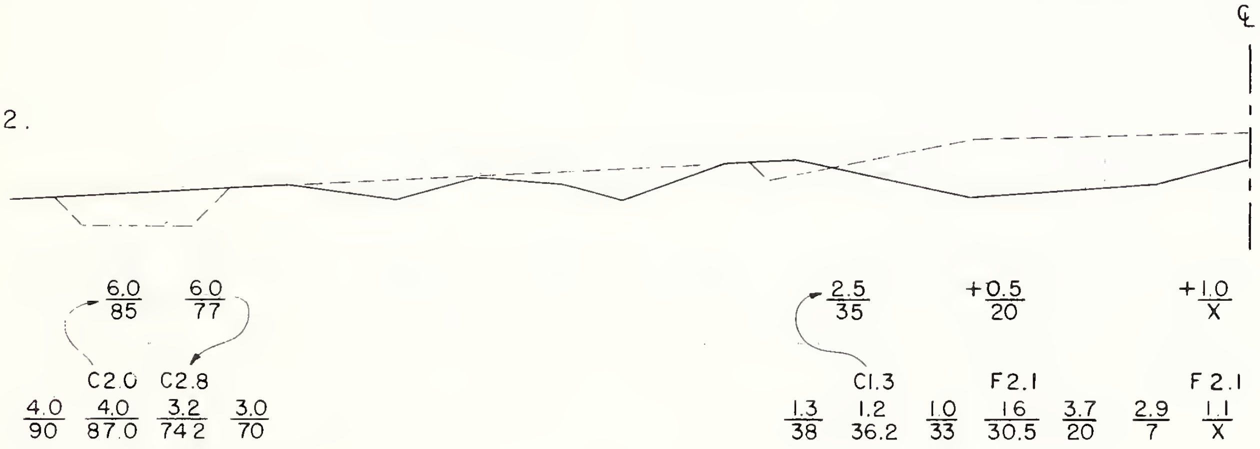


(CASE 1) THIS ILLUSTRATES A CHANNEL CHANGE AND DIKE, WIDELY SEPARATED FROM THE ROADWAY, AND HOW THE NOTES CAN BE RECORDED FOR EASE IN COMPUTER OPERATION. THE TWO SITUATIONS SHOWN ON THIS PLATE ARE THE ONLY ANTICIPATED CASES THAT WILL REQUIRE THE USE OF ARROWS. THE ARROWS CAN BE AVOIDED BY ENTERING IN THE TEMPLATE LINE ALL OF THE INTERSECTIONS OF TEMPLATE AND GROUND FROM 39.6 TO 73.3. IT APPEARS BETTER TO USE THE ARROWS.

THE PUNCH CARD OPERATOR WOULD START THE TEMPLATE READINGS AT 87.3 AND FOLLOW THE ARROWS TO CENTERLINE, AND BEYOND. GROUND WOULD START AT 90 AND BE PUNCHED STRAIGHT THROUGH TO CENTER.

ARROWS MUST POINT FROM LEFT TO RIGHT, REGARDLESS OF WHETHER SECTION IS LEFT OR RIGHT OF CENTERLINE.

Case 2.

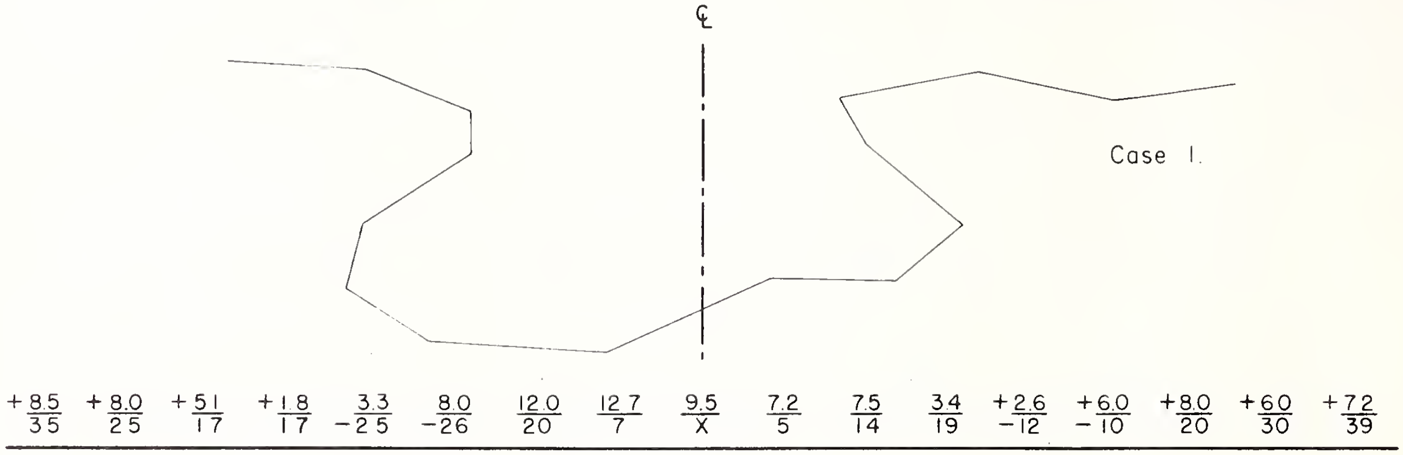


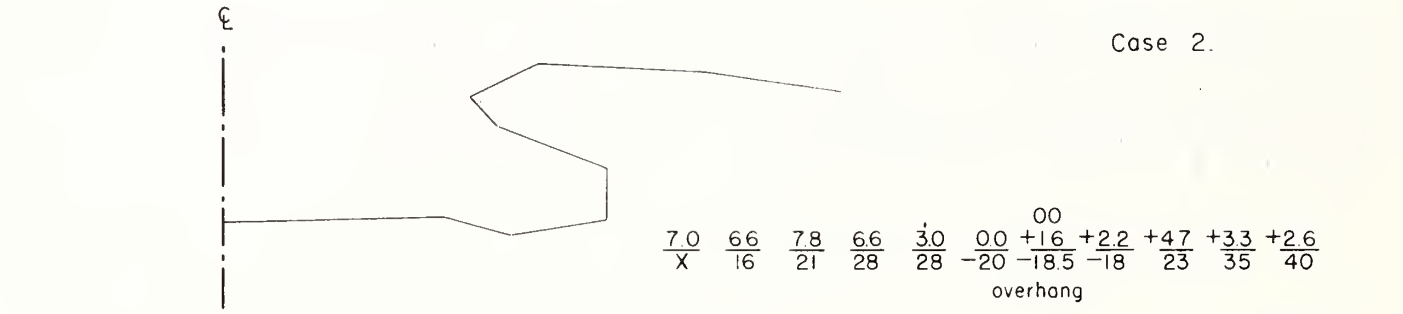
(CASE 2) THIS CASE IS SIMILAR TO CASE 1, BUT NO DIKE. IT IS CLEARLY UNDERSTOOD THAT THERE WILL BE NO GRADING DONE BETWEEN 38 AND 70. THE GROUND LINE SHOTS ARE SKIPPED BETWEEN THOSE TWO POINTS. THE TEMPLATE CARD WILL START AT 87.0 AND FOLLOW THE ARROWS TO CENTERLINE, AND BEYOND. THE DASHED LINE BETWEEN 38 AND 70 SHOWS THAT NOTHING WILL BE PUNCHED AS TO TEMPLATE AND GROUND BETWEEN THOSE TWO POINTS. THE SAME PROCEDURES CAN BE APPLIED TO FRONTAGE ROADS.

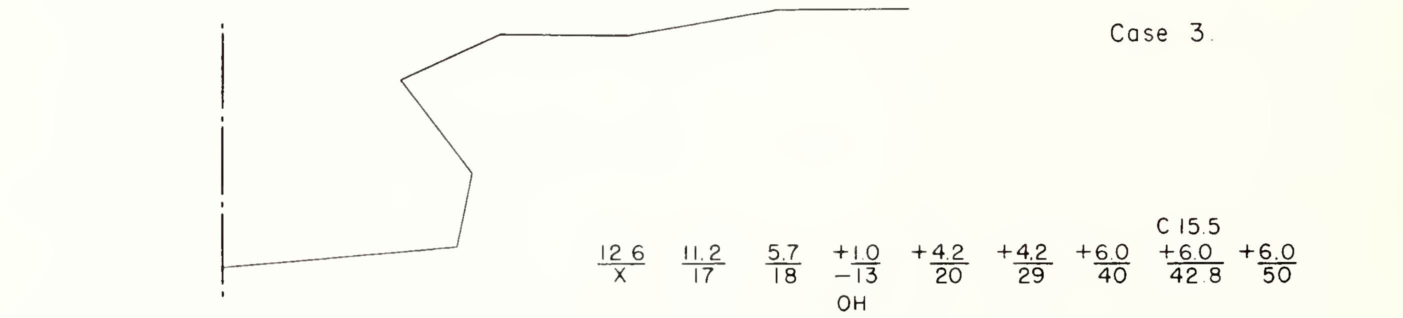
THERE WILL BE CASES WHERE THE ENGINEER WILL PREFER TO RUN SPECIAL CENTERLINE OR BASE LINE FOR THE CHANNEL CHANGES, ETC.

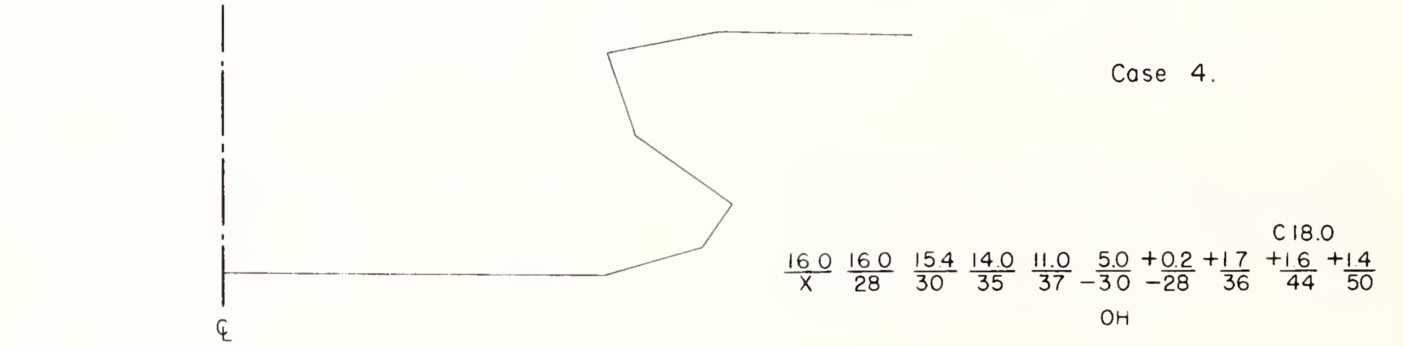
PLATE VII-05-10
DATE MARCH 31, 1964

OVERHANG









THIS PLATE ILLUSTRATES HOW NOTES SHOULD BE RECORDED WHEN AN OVERHANG OR CAVE IS ENCOUNTERED.

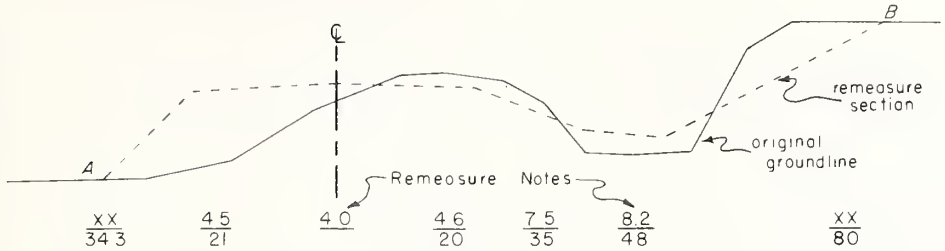
CASE 1 SHOWS AN OVERHANG ON EACH SIDE OF CENTERLINE. THE NOTES SHOW HOW THE GROUND LINE CAN BE RECORDED SO AS TO DETERMINE QUANTITIES. NOTE THE MINUS DISTANCE READINGS AT 25 AND 26 LEFT OF CENTERLINE AND AT 12 AND 10 RIGHT OF CENTERLINE. ANY HORIZONTAL READING THAT REVERSES, READING FROM THE LEFT, BEARS A MINUS SIGN (-25). THE READINGS AT 25 AND 7 ARE PLUS WITHOUT THE SIGN. WHEN THE RIGHT SIDE IS RECORDED, THE MINUS SIGN OCCURS WHEN THE DISTANCE FROM CENTERLINE DECREASES -- THUS 12 AND 10 SHOULD HAVE A MINUS SIGN. THE MINUS SIGN, IN SUCH CASES, INDICATES A REVERSE DIRECTION IN GROUND LINE AND NOTHING ELSE.

DATE MARCH 31, 1964

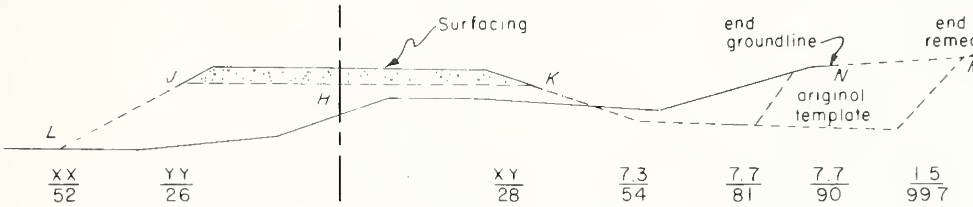
REMEASURE

REMEMBER

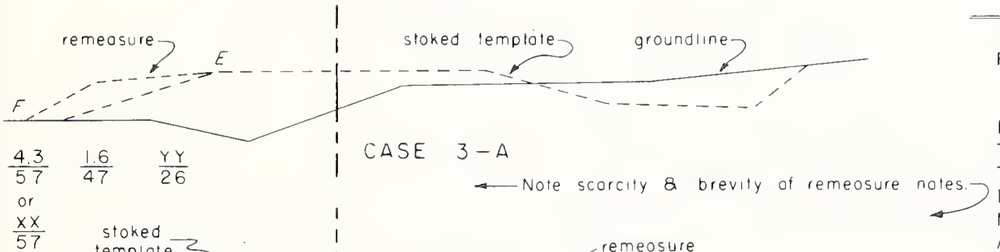
1. DO NOT USE "XX" AS A ROD READING UNLESS THE GROUNDLINE NOTES EXTEND BEYOND THE REMEASURE DISTANCE.
2. "XX" CAN BE USED ONLY ON MOST EXTREME REMEASURE POINTS.
3. "XX" CAN BE USED ONLY ONCE ON THE SAME SIDE OF CENTERLINE PER SECTION.
4. "YY" CAN BE USED ONLY ONCE ON THE SAME SIDE OF CENTERLINE PER SECTION.
5. ALL SHOTS, BOTH SIDES, MUST BE FARTHER FROM CENTERLINE THAN THE "YY" SHOT.
6. A "YY" READING MUST LIE ON THE STAKED TEMPLATE SHOULDER ONLY.



CASE I

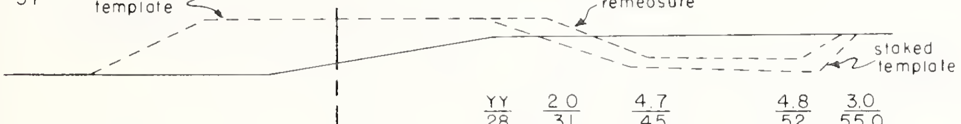


CASE 2

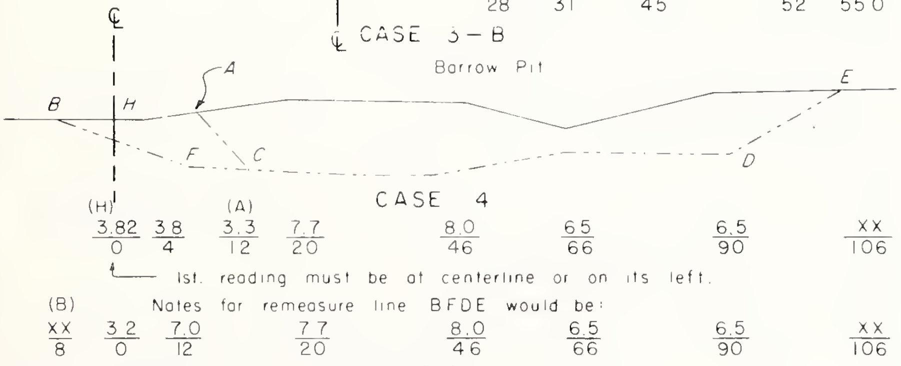


CASE 3-A

Note scarcity & brevity of remeasure notes.



CASE 3-B


℄
A
Borrow Pit
B
H
E
F
C
D
(H)
3.82/0
3.8/4
(A)
3.3/12
7.7/20
8.0/46
6.5/66
6.5/90
XX/106
1st. reading must be at centerline or on its left.
(B)
Notes for remeasure line BFDE would be:
XX/8
3.2/0
7.0/12
7.7/20
8.0/46
6.5/66
6.5/90
XX/106
Rod reading can be used at "8" but XX is best

CASE 4

IT WILL BE NECESSARY THAT PARTS OF SOME PROJECTS, AND SOMETIMES ALL, BE REMEASURED IN ORDER TO DETERMINE CORRECT PAY QUANTITIES. IT ALWAYS OCCURS WHEN BORROW PITS ARE USED.

REMEASUREMENT CAN BE CONDUCTED JUST THE SAME AS ORIGINAL CROSS-SECTIONING, ONLY EASIER. IT IS MORE LIKE LOCATION CROSS-SECTIONING. REMEASURE NOTES MUST NOT BE INSERTED INTO THE ORIGINAL GROUNDLINE NOTES.

THE ENGINEER MAY USE ANY H.I. HE WISHES. IT NEED NOT TIE INTO THE CONSTRUCTION STAKING H.I. IT IS NECESSARY, HOWEVER, TO REMEASURE AT THE SAME STATIONS AT WHICH CONSTRUCTION STAKING WAS CROSS-SECTIONED. IF IT IS NECESSARY (E.G., ROCK WORK) TO ADD SOME NEW SECTIONS ON REMEASURE THAT WERE NOT IN THE ORIGINAL STAKING, THE FIELD ENGINEER MUST INTERPOLATE THE GROUNDLINE SECTIONS, DISTANCES, ETC., JUST LIKE THE GROUNDLINE SHOTS ON STAKING. INTERPOLATED SECTIONS SHOULD BE SUBMITTED AS SUPPLEMENTARY NOTES.

CASE 1. THIS IS A NORMAL CASE WHERE THE ENGINEER ELECTED TO USE DISTANCES ONLY, AND "XX" FOR RODS, AT THE CATCH POINTS, A AND B. THIS IS COMPLETELY IN ORDER INASMUCH AS THE GROUNDLINE EXTENDS BEYOND THE REMEASURED SECTION.

THE LAST SHOT RIGHT AND LEFT, WHERE GROUND AND REMEASURE INTERSECT, NEEDS DISTANCE ONLY, PROVIDING THE REMEASURE SECTION IS COINCIDENT WITH AN ORIGINAL GROUNDLINE SECTION AND FURTHER PROVIDING THAT ORIGINAL GROUND NOTES GO FARTHER OUT THAN THE REMEASURE SECTION. IT IS BEST, INSTEAD OF ENTERING A ROD READING, TO WRITE "XX" AS SHOWN.

CASE 2. WHEN THE REMEASURE SECTION EXTENDS FARTHER FROM CENTERLINE, EITHER SIDE, THAN THE ORIGINAL GROUNDLINE NOTES RECORD, THEN BOTH ROD READING AND DISTANCE AT M IS NECESSARY. THE COMPUTER WILL CONNECT POINTS N AND M AUTOMATICALLY AND DETERMINE THE END AREA. SUCH A READING AS 1.5/99.7 IS NECESSARY. THE USE OF XX/99.7 RESULTS IN NO PROGRESS. THE USE OF XX AT L (XX/52) IS SATISFACTORY.

WHEN THE ROADWAY SURFACE IS COVERED WITH GRAVEL (E.G.) AND IS INACCESSIBLE FOR REMEASURE READINGS, THE USE OF "YY" IS ACCEPTABLE, SUCH AS YY/26 AND YY/28 AT J AND K. THE DISTANCE MUST BE THE SAME AS IN THE STAKED TEMPLATE NOTES. THE USE OF "YY" IN THE REMEASURE NOTES WILL TELL THE COMPUTER TO USE THE STAKED TEMPLATE NOTES BEGINNING WITH THE FIRST "YY" AND ENDING WITH THE NEXT "YY" (BEGIN YY/26, END YY/28) (SEE CASE 3 FOR A VARIATION). "YY" MUST NOT BE USED ANYWHERE EXCEPT ON THE SHOULDER. ALL ACTUAL REMEASURE READINGS (ROD/DISTANCE OR XX/DISTANCE) MUST BE FARTHER FROM CENTERLINE, EITHER SIDE, THAN A YY READING.

THE USE OF YY READINGS IS NOT PERMISSIBLE IF THE FINISHED ROADWAY IS NOT IN CONFORMITY TO THE ORIGINAL TEMPLATE.

CASE 3 - A AND B. THIS ILLUSTRATES ANOTHER SITUATION THAT COULD HAPPEN ON EITHER SIDE OF CENTERLINE. THE LEFT SIDE, IN THE SKETCH, NEEDS REMEASURE BUT THE RIGHT DOES NOT, BECAUSE IT WAS CONSTRUCTED IN CONFORMITY TO THE ORIGINAL TEMPLATE. THIS IS INDICATED BY THE SUGGESTED TYPICAL NOTES.

THE READING AT E MUST BE LIKE YY/26.

LIKEWISE THE READING AT F COULD BE XX/57 INSTEAD OF 4.3/57.

CASE 3-B ILLUSTRATES THAT THE REMEASURE OR THE STAKED TEMPLATE, CAN BE ON EITHER SIDE OF CENTERLINE.

CASE 4. THIS ILLUSTRATES A BORROW PIT THAT WAS ORIGINALLY CROSS-SECTIONED ON BOTH SIDES OF A BASE-LINE OR CENTERLINE. WHEN EXCAVATION WAS COMPLETED, THE REMEASURED SECTION LOOKED LIKE ACDE. XX CAN BE USED AT E, XX/106, BUT NOT AT A: ROD AND DISTANCE ARE NECESSARY AT A; NOTES MUST BEGIN AT CENTERLINE OR LEFT OF CENTERLINE; XX CANNOT BE USED TWICE ON THE SAME SIDE OF CENTERLINE.

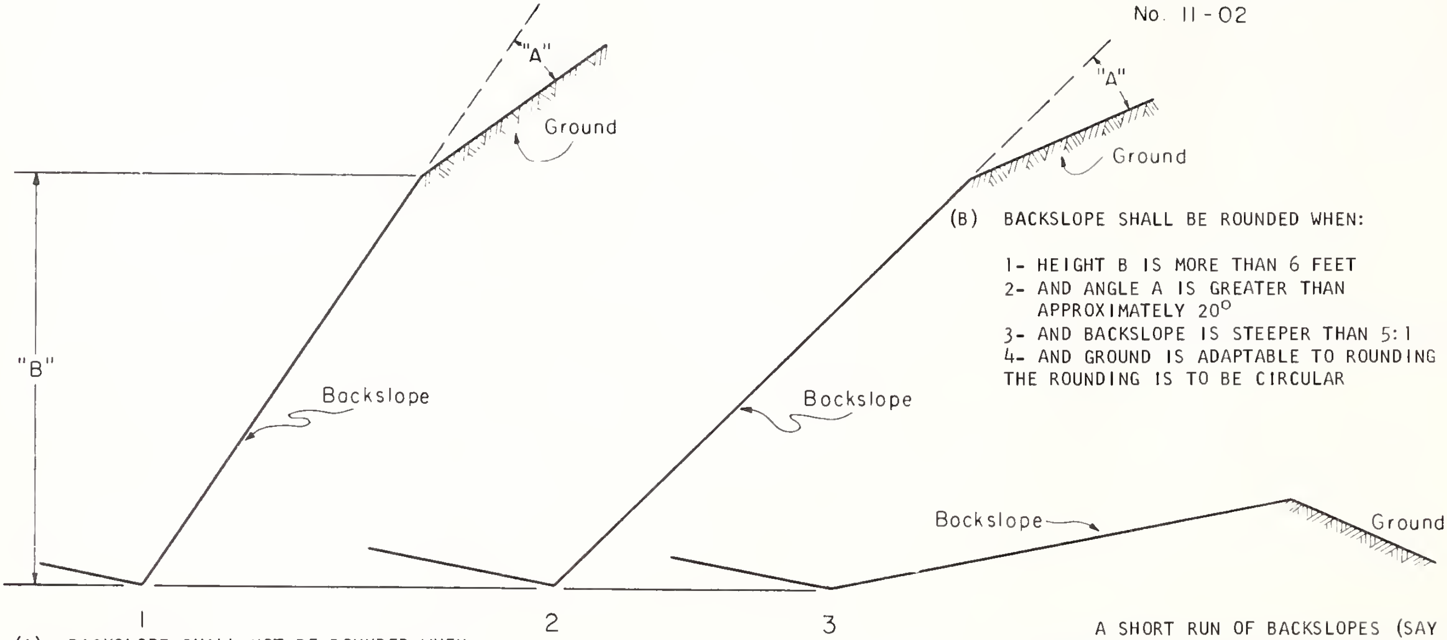
IF THE REMEASURED SECTION WERE REPRESENTED BY BFCDE, THEN XX COULD HAVE BEEN USED AT B, AS XX/8 OR 4.0/8, AS THE ENGINEER DECIDES. BUT THE FIRST XX MUST BE ON THE OPPOSITE SIDE OF CENTERLINE FROM THE SECOND XX.

PLATE NO. VII 05-12
DATE MARCH 31, 1964

SAMPLE CONDITIONS

"BACKSLOPE ROUNDING"

See Standard Drawing
No. 11-02



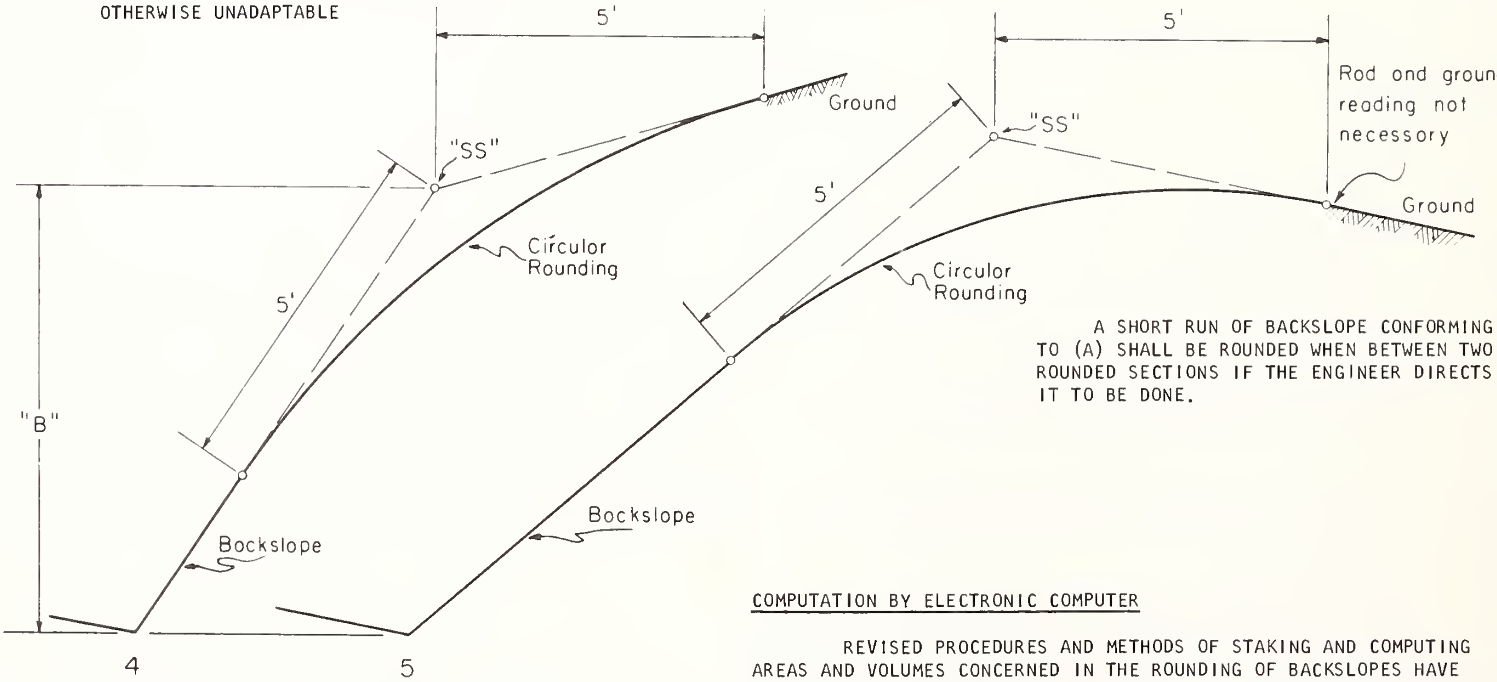
(B) BACKSLOPE SHALL BE ROUNDED WHEN:

1- HEIGHT B IS MORE THAN 6 FEET
2- AND ANGLE A IS GREATER THAN APPROXIMATELY 20°
3- AND BACKSLOPE IS STEEPER THAN 5:1
4- AND GROUND IS ADAPTABLE TO ROUNDING
THE ROUNDING IS TO BE CIRCULAR

(A) BACKSLOPE SHALL NOT BE ROUNDED WHEN:

1- HEIGHT B IS 6 FEET OR LESS
2- ANGLE A IS LESS THAN APPROXIMATELY 20°
3- BACKSLOPE IS 5:1 OR FLATTER
4- NATURAL SOIL IS ROCK, HEAVY GRAVEL OR OTHERWISE UNADAPTABLE

A SHORT RUN OF BACKSLOPES (SAY 50 FEET OR LESS) CONFORMING TO (B) SHALL NOT BE ROUNDED IF THE ENGINEER DIRECTS THAT ROUNDING NOT BE DONE.



A SHORT RUN OF BACKSLOPE CONFORMING TO (A) SHALL BE ROUNDED WHEN BETWEEN TWO ROUNDED SECTIONS IF THE ENGINEER DIRECTS IT TO BE DONE.

WHEN ROUNDING AREAS ARE COMPUTED BY THE ELECTRONIC COMPUTER, THE PROGRAM IS SO ARRANGED THAT, IF THE DISTANCE FROM THE SLOPE STAKE (SS) TO THE FARTHEST READING FROM CENTERLINE IS LESS THAN 5 FT., THE EXTENT OF ROUNDING WILL BE LIMITED TO THAT DISTANCE (E.G.--SS TO LAST SHOT = 3', ROUNDING WILL BE 3 x 3).

IT IS NOT NECESSARY, AS FAR AS AREA COMPUTATIONS ARE CONCERNED, TO TAKE A ROD AND GROUND READING AT THE OUTSIDE EXTENT OF ROUNDING.

THE ENGINEER WILL STAKE BEGINNING AND ENDING OF EACH SECTION OF ROUNDING, WITH LATH OR STAKES OR OTHER SUITABLE MEANS, FOR THE CONTRACTOR'S GUIDANCE

COMPUTATION BY ELECTRONIC COMPUTER

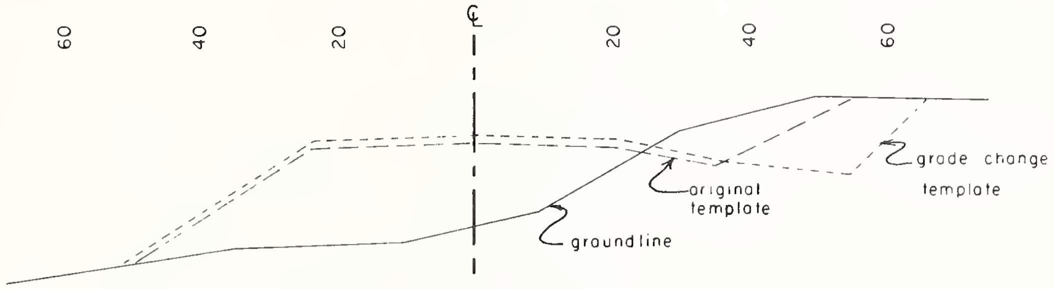
REVISED PROCEDURES AND METHODS OF STAKING AND COMPUTING AREAS AND VOLUMES CONCERNED IN THE ROUNDING OF BACKSLOPES HAVE BEEN CONSIDERABLY SIMPLIFIED. THE METHODS SET FORTH HEREIN HAVE BEEN DEVISED FOR THE PURPOSE OF SIMPLIFYING THE PROCEDURES AS MUCH AS POSSIBLE, AS FAR AS THE ENGINEER IS CONCERNED. ONE CASE WHERE ROUNDING WOULD NOT BE REQUIRED OR PERFORMED, NOT SHOWN HEREON, IS THAT OF INSUFFICIENT RIGHT-OF-WAY WIDTH. THE COMPUTER WILL COMPUTE ROUNDING QUANTITIES IN ACCORDANCE WITH THE DESIGN SHOWN HEREON.

IT IS NOT NECESSARY TO TAKE A READING AT A POINT FIVE FEET BEYOND THE SLOPE STAKE JUST BECAUSE OF ROUNDING. THE COMPUTER WILL MAKE THE COMPUTATION WITHOUT THAT IF THERE IS A READING BEYOND THE SLOPE STAKE -- IT SHOULD BE AT LEAST FIVE FEET.

IF THE ENGINEER WANTS ROUNDING QUANTITIES COMPUTED, HE MUST SAY SO IN HIS LETTER OF TRANSMITTAL; OTHERWISE THE COMPUTATION WILL NOT BE MADE. IF THERE ARE ANY EXCEPTIONS, LIKE STATION XX TO STATION YY, LEFT OR RIGHT, HE MUST SO STATE.

PLATE NO. VII - 05 - 13
DATE MARCH 31, 1964

GRADE CHANGE



Sample original staking notes.

			$\frac{10.4}{22}$		$\frac{10.0}{0}$		$\frac{10.4}{20}$			$\frac{13.4}{35}$			
Ground	F16.6				F12.2			F1.2				C10.0	Template
$\frac{30.3}{68}$	$\frac{27.0}{46.9}$	$\frac{25.5}{35}$		$\frac{24.5}{10}$	$\frac{22.2}{0}$	$\frac{20.0}{10}$		$\frac{11.6}{26.0}$	$\frac{8.5}{30}$		$\frac{3.4}{50}$	$\frac{3.4}{55.0}$	$\frac{3.4}{76}$

SAMPLE GRADE-CHANGE NOTES

USE THE FOLLOWING PROCEDURE ONLY WHEN GROUNDLINE NOTES HAVE BEEN PUNCHED.

	F18.0						C11.0
TEMPLATE	$\frac{27.4}{49.0}$	$\frac{9.4}{20}$	$\frac{9.0}{0}$	$\frac{9.4}{20}$	$\frac{12.4}{35}$	$\frac{14.4}{55}$	$\frac{3.4}{66.0}$

THIS ILLUSTRATES THE ENTRY OF THE TEMPLATE NOTES, AND THESE ONLY, IN AND ON ENTIRELY DIFFERENT PAGES OF THE NOTEBOOK. THE GROUNDLINE NOTES ARE NOT AMENDED IN ANY WAY. THE SLOPE STAKE READINGS FOR THE TWO OUTSIDE CATCHES ARE ENTERED INTO THE TEMPLATE BLOCK RATHER THAN INTO THE GROUNDLINE BLOCK. THE INSLOPE CATCH AT 27.0' RIGHT COULD BE ENTERED INTO THE NEW TEMPLATE NOTES, BETWEEN 20' AND 35' RIGHT, IF THE ENGINEER DESIRES.

NOTATION MUST BE MADE, IN THE ORIGINAL NOTES, THAT A GRADE CHANGE HAS BEEN MADE.

THE NEW TEMPLATE NOTES MUST BE PROPERLY IDENTIFIED AND SUPPLEMENTED BY SUCH INFORMATION AS STATION, GRADE, H.I., AND ANY OTHER PERTINENT DATA.

IF REVISED QUANTITIES ARE REQUIRED, SEND THE NEW NOTES TO HELENA FOR COMPUTATION. THEY WILL BE BLENDED WITH THE ORIGINAL NOTES.

3. Distance Out Of Sequence

It occasionally happens that a distance reading is out of proper sequence: thus 00, 10, 15, 25, 20, 31, 36. Are the readings at 25 and 20 reversed? Should the 20 be 28 or 30? Is there a cave or overhang? If the readings are true, explain. Be sure to edit the notes for such occurrences.

4. Catch Point Not Defined

Occasionally the catch points, particularly the outside fill or cut, are not clearly defined or readily discernible. It is imperative that all note records use a standard practice in the case of outside catches. See page 30-18A, Paragraph "R" and page 30-18 B. Leave at least one blank space each side of the outside catch; enter the amount of cut or fill above the rod reading.

5. Excavation Without Centerline

Occasionally a borrow area is cross-sectioned without a centerline or baseline. This usually happens as an extension of roadway sections off the roadway centerline. It is essential that every set of cross-sections have a centerline or baseline. See page 30-18 D.

6. Wrong H.I.

Sometimes the notekeeper will, in transposing the H.I. to the next page, get the number mixed, usually the first two digits e.g., 3152.69 carried forward and written as 4152.69. When the cards are punched using an erroneous H.I. some incorrect answers are certain to result. This should be carefully watched. Sometimes this goes right on by a Bench Mark without correction.

7. H.I. in Wrong Column

Occasionally a recorder will write the H.I., when starting a new page, in some column other than the H.I. column. This causes trouble in card punching because all rod readings are reduced to elevation. Erroneous H.I. produce erroneous elevations and end areas.

8. Decimal Points

Now and then a recorder will forget to enter a decimal point in a rod reading or distance, or enter a decimal point where there should be none. This should be watched carefully. They cause delay and wrong answers.

E. Road Approaches, Dikes, etc.

Most road approaches and small dikes will be constructed by use of only a few guide and reference stakes. There may be occasions, however, when it will be necessary to run out and stake the approach or dike, similar to a roadway. When this occurs, treat it just like a roadway, using centerline, shoulders, slope stakes, etc. The quantities can be included in the roadway mass if desired.

F. Bluetops

The operation of construction staking is not complete until the roadway, ditches and other attendant facilities have been completed to designed section. Finishing stakes, popularly called "bluetops", shall be set to line and grade as the roadway grading progresses from rough toward finish. The top should never vary more than 0.05 ft. from true elevation. The roadway centerline must be run in by transit and chain and the grades established by level. A line of bluetops is essential for centerline and each shoulder. These three lines will suffice for narrower roadways. There will be many occasions, particularly on the Interstate System with very wide sections, where five lines of bluetops will be necessary---centerline, each shoulder, and about halfway between centerline and shoulder.

There will be occasions when ditch or channel flow lines should be bluetopped. This is especially essential when runoff grades are very nearly flat.

All bluetops must be set true to line and grade. It is especially important to have shoulder bluetops true to line to attain a good appearing shoulder line. It is essential that bluetops be set to true grade line, and the grade work finished accordingly, so that a smooth riding surface will be the result.

G. Corrections to Notes

There will be occasions when the cross-section notes must be amended or supplemented or otherwise revised after Data

Processing Bureau has computed the quantities. Data Processing tabulates all of the cross-section data, both template and groundline, on cards and saves them for future use. Remeasure is one such use.

If the engineer finds it necessary to change the groundline record, such changes, generally, should be done with red pencil so that they are easy to find. If the changes are reflected on completely new sheets, like borrow widening or such cases, the notes need not be in red, but should be clearly marked and noted that the change is to be considered when computing remeasure quantities.

When remeasure notes are sent to the Construction Bureau for computation of quantities, it may or may not be necessary to also send the groundline notes. If the groundline notes have been submitted once for original computations, and no changes or additions were made subsequently, then they need not be re-sent to Helena. If only a few changes were made, comparatively speaking, it might suffice to send in only the sheets or pages which were modified. The field engineer should exercise his best judgment in making this determination. The answers received back from the Data Processing Bureau will conform to the basic information submitted to it.

H. Unusual Situations

Unusual problems and situations occur, occasionally, which are not covered and discussed in this manual. It is impossible to anticipate everything and these situations may occur only once in a "coon's age".

When such a situation or problem is encountered, and quantities are to be determined by the electronic computer, the field engineer should immediately contact the Construction Bureau in Helena and reach an agreement as to procedure and method to follow. There have been cases where the field engineer went to a lot of work to prepare notes for subsequent computations when he fully wasted his time and that of personnel in headquarters, mostly because he was not fully cognizant of what could or could not be done by the existing computer program. Several of the problems had an easy solution when attacked by a person having full knowledge.

So---don't hesitate to try the Construction Bureau if the Manual does not provide the solution.

I. Data Transmittal

When staking and remeasure notes are submitted to Helena for computation of areas, volumes, etc., the package must be addressed to:

Construction Bureau
Department of Highways
Helena, Montana 59601

The package must be identified on the outside, near lower left corner, by project number and types of notes.

e.g., F 192(7)
Cross Section Notes

It is also necessary that a memorandum of transmittal be submitted in duplicate, separately from the notes. The memorandum shall contain such information as project number, type of notes (construction, remeasure, etc.) stating coverage, and any other pertinent data. The Construction Bureau will transmit the data to the Data Processing Bureau. The requested information will be sent back to the field engineer as soon as processing has been completed. All contact with the Data Processing Bureau will be coordinated through the Construction Bureau.

Pages 30-18"O" thru 30-18"S" show samples of coding sheets used to submit various forms of data to be key punched for electronic processing.

EXPLANATORY NOTES FOR PLATE NO. VII-05-01

THESE NOTES EXPLAIN THE ENCIRCLED LETTERS, SHOWN IN VARIOUS PLACES ON THE EXEMPLARY CROSS-SECTION NOTES ON PLATE VII-05-01.

-A- ALL ROD READINGS MUST BE WRITTEN TO THE NEAREST 0.1 (TENTH) FOOT, EVEN WHEN THE READING IS AN EXACT FOOT, SUCH AS 9.0. DECIMAL POINTS MUST BE CLEARLY SHOWN. THE ONLY SIGN TO PRECEDE A ROD READING, GENERALLY, IS A '+" SIGN: OTHER READINGS WILL BE UNDERSTOOD TO BE (-) MINUS. (SEE NOTE -T-.)

-B- RECORD DISTANCES TO THE NEAREST FOOT (25) FOR MOST CONDITIONS. THERE WILL BE CASES WHEN IT WILL BE NECESSARY TO RECORD TO THE NEAREST 0.1 (TENTH) FOOT (31.8), SUCH AS SLOPE STAKES, CURBS, IMMOVABLE STRUCTURES, ETC. USE DECIMAL POINTS WHEN SHOWING DISTANCES LESS THAN ONE FOOT (0.7).

-C- THE H.I. (HEIGHT-OF-INSTRUMENT) MUST BE ENTERED IN THIS COLUMN AT ALL TIMES. IT NEED NOT ALWAYS BE AT THE TOP OF THE PAGE. IF A TURN IS RECORDED NEAR THE MIDDLE OF THE PAGE, THE H.I. WOULD OCCUR THERE, BUT IN THIS COLUMN. THE PUNCH CARD OPERATORS COULD MISS IT QUITE EASILY IF IT IS CARRIED ELSEWHERE. WHEN H.I. IS CARRIED FORWARD FROM ONE PAGE TO THE NEXT, ENTER IT AS SHOWN AT C. WHEN A TURN IS MADE, OR B.M. CHECKED INTO, ENTER AS SHOWN AT BOTTOM OF THE COLUMN. THE RECORDER ALWAYS MUST BE CAREFUL TO RECORD H.I. IN SIX FIGURES. A COMMON ERROR IS TO INCORRECTLY COPY THE FIRST TWO FIGURES AND THUS BE OFF A HUNDRED FEET OR MORE. THE OTHER HEADINGS (+, -, ELEV.) APPEAR TO BE SELF-EXPLANATORY.

-D- EACH DAYS WORK SHOULD SHOW THE NAMES OF THE PERSONNEL DOING THE STAKING AND THE TYPE OF WORK EACH PERSON DOES -- SUCH AS INSTRUMENT, ROD, CHAIN, ETC. IF A CHANGE IN PERSONNEL IS MADE DURING THE DAY, IT MIGHT BE DESIRABLE TO MAKE A NOTATION TO THAT EFFECT.

-E- IT IS RECOMMENDED THAT THE "REMARKS" SPACE BE USED AS OCCASION DICTATES. WEATHER CONDITIONS AND TEMPERATURE SHOULD BE NOTED EACH DAY; MORE THAN ONCE, IF NOTED CHANGES OCCUR.

-F- THE PROJECT NUMBER OR IDENTIFICATION SHOULD BE SHOWN FREQUENTLY. THE ENGINEER WOULD NOT BE WRONG IF HE ENTERED IT ON EVERY PAGE.

-G- THE ENGINEER MAY DEVISE HIS OWN SYSTEM OF PAGE NUMBERING. POSITIVE IDENTIFICATION IN PROPER SEQUENCE IS IMPORTANT.

-H- THE DATE SHOULD BE ENTERED, AT THE LEAST, AT THE BEGINNING OF EACH DAYS WORK.

-I- BENCH MARKS AND TURNING POINTS (B.M. & T.P.) SHOULD BE RECORDED AS SHOWN. THE METHOD SHOWN IS USED BY MOST ENGINEERS. A COMPLETE DESCRIPTION MUST BE PROVIDED AS TO TYPE AND LOCATION OF B.M. T.P.'S ARE NOT SO IMPORTANT; MOST ARE TEMPORARY FOR THE ONE TURN; SOMETIMES THEY MAY BE REFERRED TO SEVERAL TIMES. THE TYPE OF USE AND REUSE SHOULD BE CONSIDERED.

-J- THIS COLUMN SHOULD BE USED, AT ALL TIMES, FOR RECORDING STATION NUMBER AND STATION PLUS NUMBER. THIS IS, OF COURSE, QUITE IN KEEPING WITH CUSTOM. THE FIRST ENTRY IN THIS COLUMN, ON ANY PAGE, SHOULD BE COMPLETE AS TO STATION AND PLUS -- E.G. -- WRITE "136+17" -- NOT JUST '+17".

-K- THE FIGURE "43.80" IS PROFILE GRADE REDUCED TO SUBGRADE ELEVATION BY THE SURFACING THICKNESS. SOME ENGINEERS WOULD PREFER TO WRITE "2143.80". THIS INFORMATION SHOULD BE INSERTED IN THIS SPACE AT ALL TIMES.

-L- A FOUR-LINE SPACE, SUCH AS 'L' AND 'M' WILL BE CALLED "QUAD-SPACE" IN FURTHER DISCUSSIONS. THE TEMPLATE RODS (GRADE RODS) AND DISTANCES ALWAYS SHOULD BE WRITTEN INTO THE SAME QUAD-SPACE AS THE STATION AND GRADE. THE TEMPLATE READINGS SHOULD SHOW ALL OF THE BREAKS IN THE COMPLETED ROADWAY SECTION, EXCEPTING THE OUTSIDE CATCH POINTS WHERE TEMPLATE INTERSECTS GROUND.

-M- THE FIRST QUAD-SPACE BELOW THE TEMPLATE NOTATIONS IS TO BE USED FOR GROUNDLINE READINGS. IT ALSO WILL CARRY SLOPE STAKE DATA AND OTHER PERTINENT INFORMATION, SUCH AS ILLUSTRATED. THE LOWER OF THE FOUR SPACES OF THE QUAD-SPACE, WHICH HAS NO VERTICAL LINES, IS TO BE USED FOR NOTATIONS SUCH AS RATE OF SLOPE (5:1 OR 5), REFERENCE (R), END CUT, ETC., ETC. THIS APPLIES TO BOTH TEMPLATE AND GROUND LINE READINGS. IT IS A FREQUENT OCCURRENCE FOR SO MANY GROUND READINGS TO BE RECORDED THAT ALL CANNOT BE ENTERED ON ONE LINE. IN SUCH CASE, PROCEED AS ILLUSTRATED ON THE RIGHT SIDE FOR STATION 15+45. ON THE RIGHT SIDE, THE FIRST LINE SHOULD READ FROM LEFT TO RIGHT, THE SECOND RIGHT TO LEFT, THE THIRD LEFT TO RIGHT, ETC. THE LEFT SIDE OF CENTERLINE WOULD BE THE OPPOSITE.

-N- ALWAYS LEAVE AT LEAST ONE QUAD-SPACE BETWEEN THE LAST QUAD-SPACE USED BY A CROSS-SECTION AND THE FIRST QUAD-SPACE USED BY THE NEXT CROSS-SECTION. DO NOT CROWD THE NOTES.

-O- REFERENCE STAKE OR REFERENCE POINT ENTRIES SHOULD BE SHOWN AS ON PLATE VII-05-01. THERE WILL BE OCCASIONS, SUCH AS A CHANNEL CHANGE NEAR THE OUTSIDE OF THE RIGHT-OF-WAY, WHEN THE ENGINEER WILL WANT THE REFERENCE POINT BETWEEN SUCH A CHANNEL AND THE ROADWAY. HE CAN WRITE "R" UNDER WHICHEVER POINT HE CHOOSES AND RECORD ON OUT TO THE DECIDED LIMIT.

-P- THE ENGINEER FREQUENTLY WILL DESIRE TO ENTER SUCH NOTES AS "END DITCH LEFT", "BEGIN CUT RIGHT", ETC., ETC. SUCH NOTES CAN BE ENTERED AS SHOWN AT STA. 15+80 LEFT SIDE. (REQUIRES A ENTIRE SECTION FOR CALCULATION)

-Q- NOTE THAT AT STA. 15+45 THE 00/11.3 WAS FOUND AND RECORDED. THERE ACTUALLY ARE THREE "00'S" AT STA. 15+80 BETWEEN CENTERLINE AND 20 FT. RIGHT; THEY WERE NOT CAUGHT. THE ELECTRONIC COMPUTER WILL INTERPOLATE THEM AUTOMATICALLY. SEE PLATE VII-05-06.

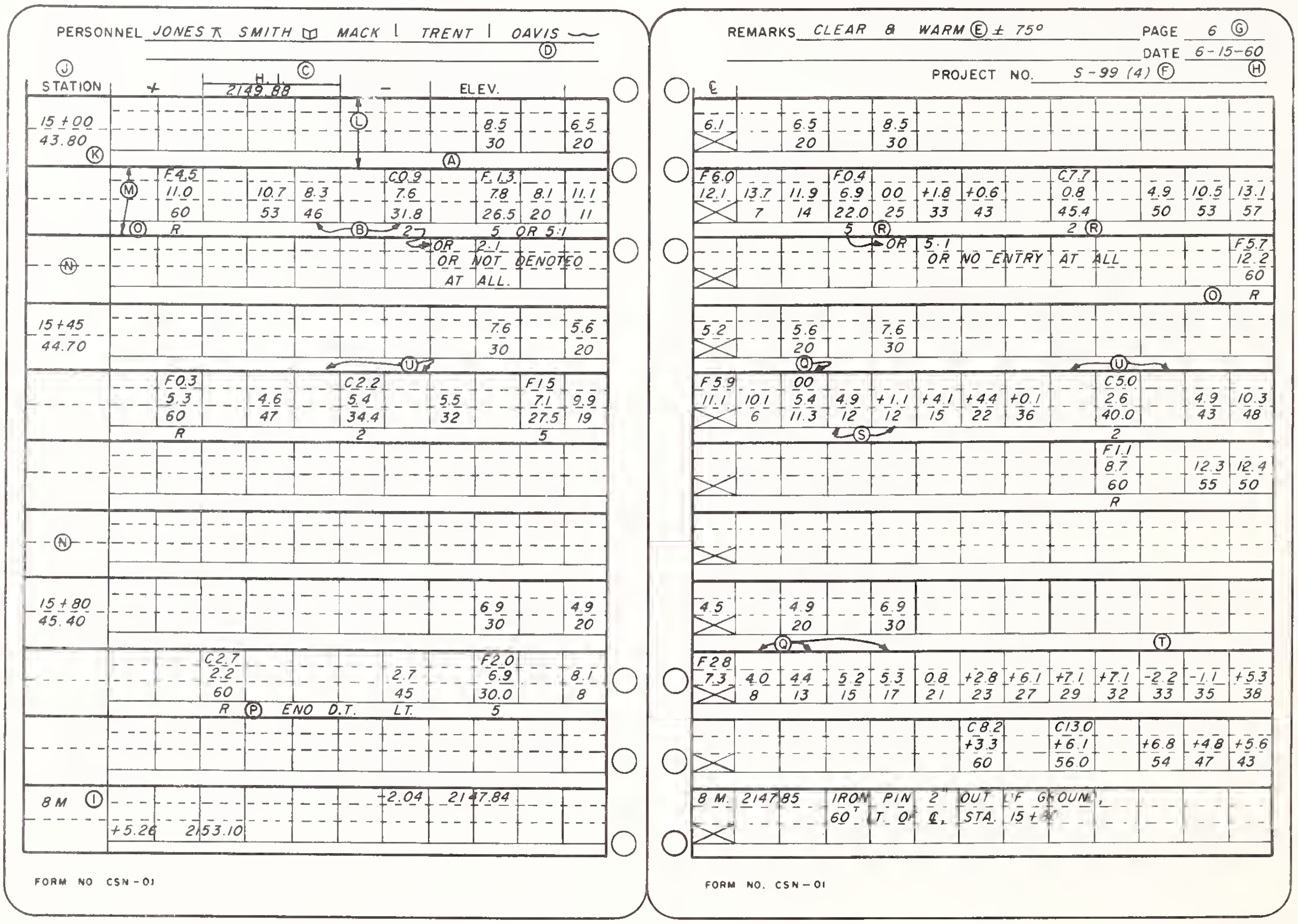
-R- SOME ENGINEERS DESIRE TO INDICATE THE RATE OF FILL SLOPE OR CUT SLOPE STAKE READINGS. SEE STA. 15+00, READINGS AT 22.0 AND 45.4. THE FILL SLOPE OR IN-SLOPE IS 5:1, RECORDED AS 5; THE BACK SLOPE IS 2:1 AND RECORDED AS 2; A DAYLITE SITUATION WOULD USE "DL" BELOW THE READING (00/5.4/35.7/DL). THE RECORDER MAY INDICATE THE RATE OF SLOPE BY EITHER "5" OR "5:1". SUCH ENTRIES ARE NOT NECESSARY TO ELECTRONIC COMPUTATION.

-S- VERTICAL FACES OR SITUATIONS CAN BE ENTERED IN THE NOTES AT THE ACTUAL DISTANCE WITHOUT HAVING TO ADD OR SUBTRACT ANY AMOUNT. THREE, BUT NO MORE, READINGS AT THE SAME DISTANCE CAN BE RECORDED IN EITHER GROUNDLINE OR TEMPLATE OR BOTH.

-T- WHEN THE ENGINEER HAS A SERIES OF PLUS RODS AND IN BETWEEN HAS ONE OR TWO MINUS RODS. IT WOULD BE VERY HELPFUL IF THE MINUS SIGN WERE ENTERED IN FRONT OF THE ROD READING, AS SHOWN AT STA. 15+80 RIGHT. SUCH AN ENTRY CLEARS UP ANY DOUBT THAT MIGHT OCCUR TO THE READER.

-U- AT LEAST ONE BLANK SPACE SHOULD BE LEFT IN THE NOTES ON EACH SIDE OF THE OUTSIDE CATCH SHOT, AS SHOWN FOR STA. 15+45. THIS MAKES IT MUCH EASIER FOR PUNCH CARD OPERATORS TO FIND THE FIRST AND LAST TEMPLATE READINGS.

"SAMPLE CROSS-SECTION NOTES"



PERSONNEL JONES ⊼ SMITH 🕮 MACK | TRENT | OAVIS ~ Ⓓ

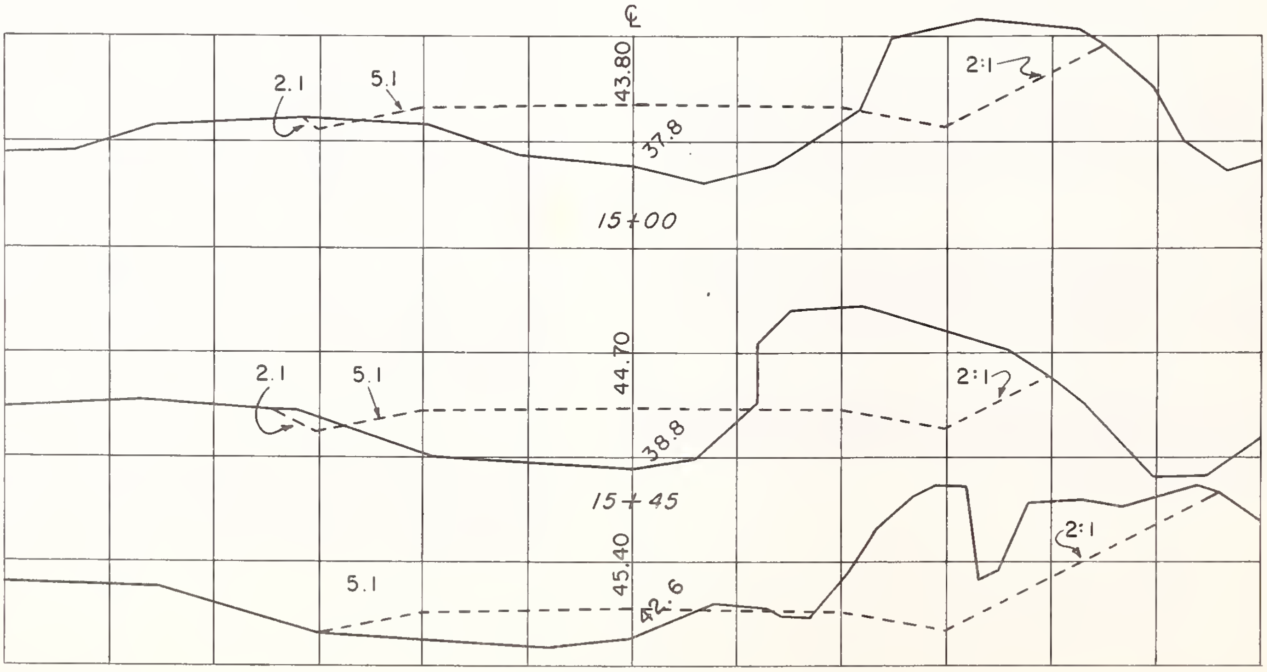
Ⓙ STATION	+		H.I. 2149.88 Ⓒ				−		ELEV.		
15 + 00 43.80 Ⓚ						Ⓛ			8.5 30		6.5 20
								Ⓐ			
	Ⓜ	F4.5 11.0 60		10.7 53	8.3 46		C0.9 7.6 31.8		F 1.3 7.8 26.5	8.1 20	11.1 11
	Ⓞ	R				Ⓑ	2		5	OR 5:1	
Ⓝ								OR OR AT	2:1 NOT ALL.	DENOTEO	
15 + 45 44.70									7.6 30		5.6 20
							Ⓤ				
		F0.3 5.3 60		4.6 47		C2.2 5.4 34.4		5.5 32		F1.5 7.1 27.5	9.9 19
		R				2				5	
Ⓝ											
15 + 80 45.40									6.9 30		4.9 20
			C2.7 2.2 60				2.7 45		F2.0 6.9 30.0		8.1 8
			R	Ⓟ ENO	D.T.		LT.		5		
8 M Ⓘ	+5.26		2153.10				-2.04	2147.84			

FORM NO CSN-01

REMARKS CLEAR & WARM Ⓔ ± 75° PAGE 6 Ⓖ
DATE 6-15-60 Ⓗ
PROJECT NO. S-99 (4) Ⓕ

℄												
6.1		6.5 20		8.5 30								
F6.0 12.1	13.7 7	11.9 14	F0.4 6.9 22.0	00 25	+1.8 33	+0.6 43		C7.7 0.8 45.4		4.9 50	10.5 53	13.1 57
			5	Ⓡ				2	Ⓡ			
				OR	5:1 OR	NO	ENTRY	AT	ALL			F5.7 12.2 60
											Ⓞ	R
5.2		5.6 20		7.6 30								
		Ⓠ							Ⓤ			
F5.9 11.1	10.1 6	00 5.4 11.3	4.9 12	+1.1 12	+4.1 15	+4.4 22	+0.1 36		C5.0 2.6 40.0		4.9 43	10.3 48
			Ⓢ						2			
									F1.1 8.7 60		12.3 55	12.4 50
									R			
4.5		4.9 20		6.9 30								
	Ⓠ									Ⓣ		
F2.8 7.3	4.0 8	4.4 13	5.2 15	5.3 17	0.8 21	+2.8 23	+6.1 27	+7.1 29	+7.1 32	-2.2 33	-1.1 35	+5.3 38
						C8.2 +3.3 60		C13.0 +6.1 56.0		+6.8 54	+4.8 47	+5.6 43
8 M.	2147.85		IRON 60'	PIN LT. OF	2" ℄,	OUT STA.	OF 15 + [illegible]	GROUND,				

FORM NO. CSN-01

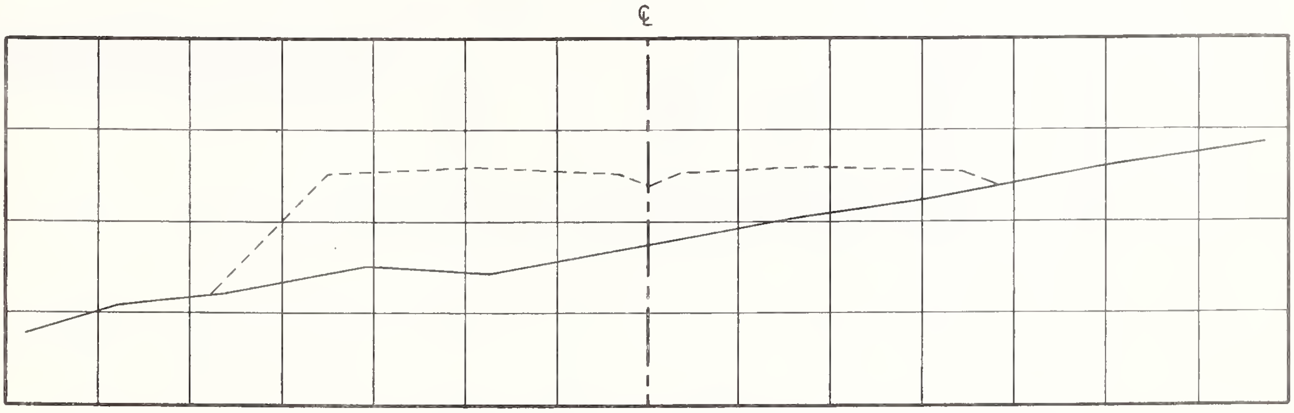


THESE SECTIONS PLOTTED FOR ILLUSTRATION ONLY

DEPARTMENT OF HIGHWAYS

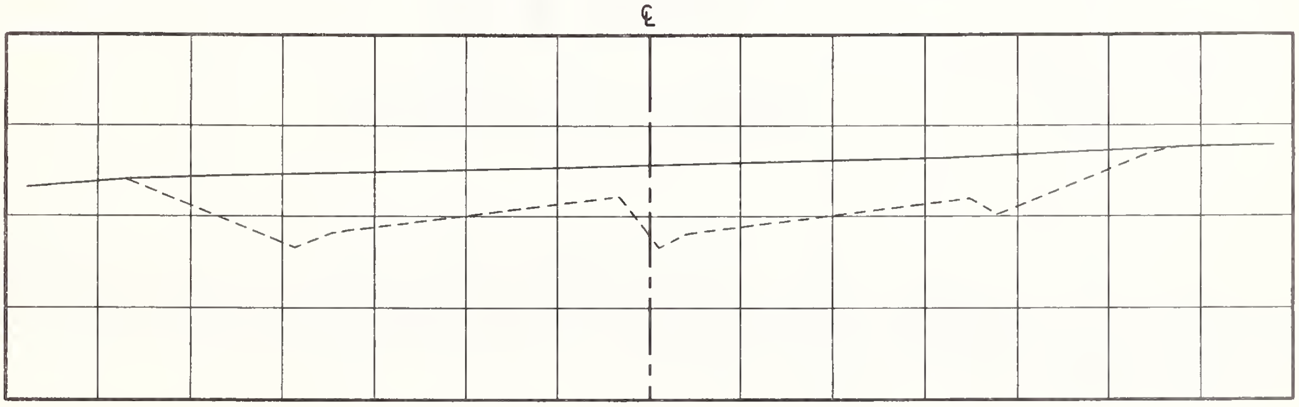
CONSTRUCTION MANUAL
PLATE NO. VII-05-02
DATE APRIL 30, 1973

"FOUR-LANE ROADWAY"



826+00 ℄ NB S BD 47+90											+1.4 69	+2.1 35	+1.5 7
												℄ SB	
				F15.8 14.4 135		12.8 115		F13.1 11.7 95.2		11.0 85	8.6 60	F11.5 9.4 35	8.1 20
				R				2:1				℄ SB	

+0.1 ☒	+1.5 7	+2.1 35	+1.4 69	-0.2 77									
		℄ NB											
F6.3 6.2 ☒	4.5 20	F5.4 3.3 35	1.6 60		00 0.2 77		+0.2 83	+1.7 100	+3.0 120		C2.6 +4.0 135		
		℄ NB			00	DITCH(DT)					R		
☒													



812+00										13.8 77	12.2 69	10.2 35	8.5 7
40.02	S=0.06/ft.											℄ SB	
			C5.0 7.2 135		00 6.5 119		C7.6 6.2 115.0		6.1 100	5.8 75	5.6 50	C4.8 5.4 35	5.3 20
			R		RN		5:1					℄ SB	

13.2 ☒	13.9 1.5	12.5 7	10.8 35	8.8 69	10.4 77								
		℄ NB											
C8.2 5.0 ☒	4.9 20	C5.7 4.8 35	4.6 50	4.2 75		C6.5 3.9 110.0		00 3.6 115		3.7 118		C5.2 3.6 135	
	℄ NB					5:1		RN				R	
☒													

THE TWO SECTIONS ILLUSTRATED ON THIS PLATE SHOW ONE WAY OF STAKING A FOUR-LANE HIGHWAY. THE UPPER SKETCH SHOWS A SECTION ON TANGENT. THE LOWER A SECTION ON A CURVE. THERE ARE SEVERAL METHODS THAT CAN BE AND ARE USED. THIS ONE SEEMS TO WORK OUT QUITE WELL. THESE SKETCHES SHOW HOW THE NOTES SHOULD BE KEPT FOR ELECTRONIC COMPUTATIONS. THEY WILL WORK EQUALLY WELL FOR HAND CALCULATOR COMPUTATION IF ALL 00'S, AS WELL AS ALL SLOPE STAKES, ARE FOUND AND RECORDED.

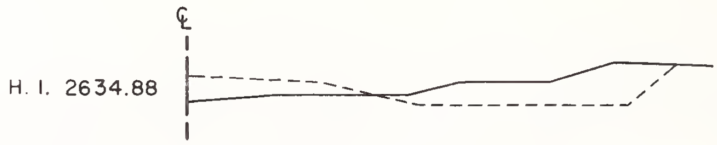
THE IMPORTANT FEATURE IS THAT ALL ENGINEERS ADOPT AND USE A UNIFORM SYSTEM OF RECORDING NOTES, SUCH AS SET OUT IN THIS SECTION OF THE MANUAL.

IF AND WHEN PARALLEL DITCHES, DIKES, ROADWAYS, ETC., ARE TO BE STAKED ALONG WITH AND AT THE SAME TIME AS THE MAIN ROADWAYS, THE TEMPLATE NOTES, AS WELL AS THE GROUND-LINE NOTES, CAN BE EXTENDED TO INCLUDE THOSE FACILITIES. PLATE VII-05-03 PROVIDES ONE METHOD OF HOW TO PROCEED.

Rev. 5-1-73

CASE I.

"BORROW WIDENING"

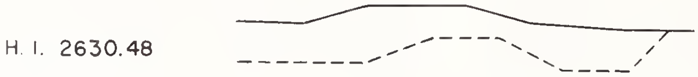


Templote $\frac{4.0}{00}$ $\frac{10.0}{20}$ $\frac{13.3}{35}$ $\frac{13.3}{68}$

Ground $\frac{12.7}{00}$ $\frac{12.0}{13}$ $\overset{\text{F 1.8}}{\frac{11.8}{29.0}}$ $\frac{11.8}{32}$ $\frac{10.0}{42}$ $\frac{10.0}{55}$ $\frac{6.6}{65}$ $\overset{\text{C 6.3}}{\frac{7.0}{74.3}}$ $\frac{7.5}{80}$

CASE 1. THIS EXAMPLE SHOWS A NORMAL FLAT BOTTOM DITCH SECTION AND THE APPROVED METHOD OF RECORDING GROUND AND TEMPLATE NOTES.

CASE 2.

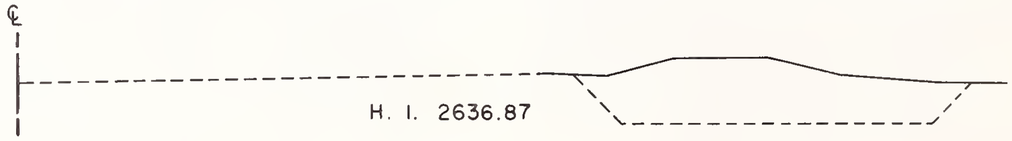


Templote $\frac{8.9}{100}$ $\frac{5.5}{110}$ $\frac{5.5}{120}$ $\frac{10.0}{130}$ $\frac{10.0}{140}$

Ground $\frac{3.3}{90}$ $\frac{0.5}{100}$ $\frac{0.5}{115}$ $\frac{3.0}{125}$ $\frac{3.8}{140}$ $\overset{\text{C 6.2}}{\frac{3.8}{146.2}}$ $\frac{3.8}{150}$

CASE 2. THE ENGINEER FOUND IT NECESSARY TO EXTEND THE CROSS-SECTION NOTES TO WIDEN THE BORROW, AND TO BUILD A BERM AND CHANNEL AFTER STAKING THE SECTION IN CASE 1. THE EXTENSIONS CAN BE STAKED USING THE SAME OR A DIFFERENT H.I., THEN CONTINUING ON TO THE RIGHT AS ILLUSTRATED UNDER CASE 2. SEPARATE NOTES ARE KEPT FOR THE EXTENSIONS BUT THE ENGINEER MUST MAKE THE EXTENSIONS STATION FOR STATION WITH THE ORIGINAL NOTES SO THE QUANTITIES INVOLVED WILL BE CALCULATED AND INCLUDED WITH THE ORIGINAL STAKED QUANTITIES. THE ORIGINAL NOTES MUST BE AMENDED BY DRAWING A RED LINE THROUGH THE C 6.3.

CASE 3.



(A) $\frac{10.0}{00}$ Templote $\frac{9.5}{80}$ $\frac{9.6}{86.2}$ $\frac{16.4}{93}$ $\frac{16.4}{140}$

(A) $\frac{10.0}{00}$ Ground $\frac{9.5}{80}$ $\overset{\text{C 6.8}}{\frac{9.6}{86.2}}$ $\frac{9.7}{90}$ $\frac{6.9}{100}$ $\frac{6.9}{115}$ $\frac{9.4}{125}$ $\frac{10.2}{140}$ $\overset{\text{C 6.2}}{\frac{10.2}{146.2}}$ $\frac{10.2}{150}$

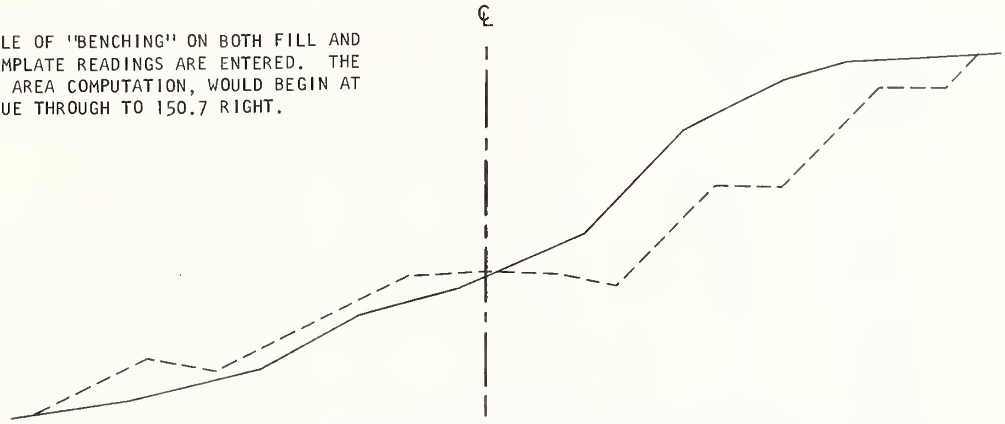
CASE 3. HERE THE ENGINEER DOES NOT WISH TO EXTEND THE ORIGINAL CROSS-SECTIONS, BUT RATHER TIE BACK TO CENTERLINE OR BASELINE BY INSERTING "FAKE" READINGS AT "A" AND REPEATING THE GROUNDLINE READINGS AT 80 AND 86.2 IN THE TEMPLATE READINGS SUCH THAT NO AREA CALCULATIONS WILL BE MADE BETWEEN 00 AND 86.2. THE VOLUMES CALCULATED IN CASE 3 WILL BE SEPARATE FROM THOSE ORIGINALLY STAKED.

THE CROSS-SECTIONS MUST BE TAKEN AT THE SAME SECTIONS AS ON CENTERLINE, IF TO BE MERGED WITH CENTERLINE QUANTITIES.

PLATE NO. VII-05-04
DATE APRIL 30, 1973

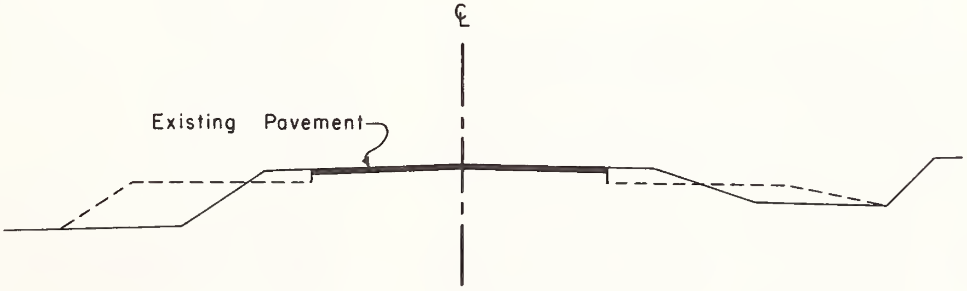
"BENCHING"

THIS IS AN EXAMPLE OF "BENCHING" ON BOTH FILL AND CUT. NOTE HOW THE TEMPLATE READINGS ARE ENTERED. THE TEMPLATE SECTION, FOR AREA COMPUTATION, WOULD BEGIN AT 137.8 LEFT AND CONTINUE THROUGH TO 150.7 RIGHT.



Template				67.6	70.6	40.6	40.0	40.4	44.4	14.4	14.9	+15.1	+14.6	
				105	85	25	X	20	40	70	90	120	140	
	F45.0	F16.4						00					C10.7	C66.0
Ground	85.0	84.0	80.0	90.0	54.2	45.5	41.6	40.1	28.2	+2.9	+17.4	+23.3	+25.3	+26.6
	145	137.8	110	70	40	9	X	5.0	30	61	90	110	150.7	155
	R													R

"PAVEMENT WIDENING"

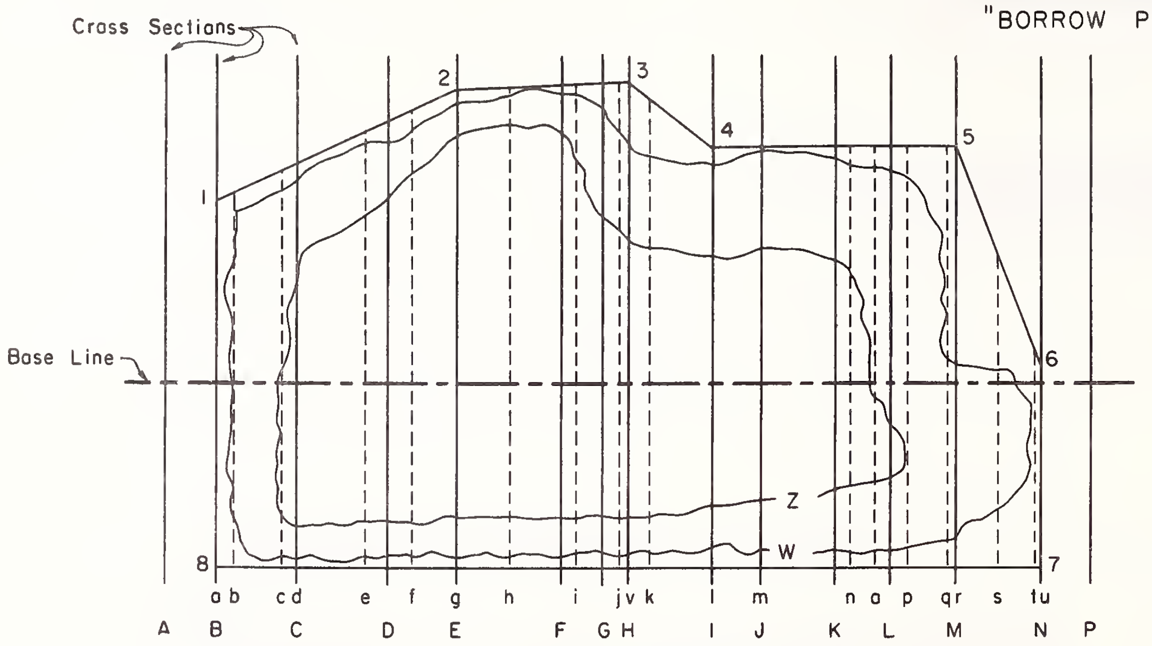


Template				3.5	2.8	2.4	2.7	3.5					
				9	9	X	9	9					
			00						00				
Ground	6.6	6.3	3.6	2.9	2.8	2.4	2.7	2.8	3.6	4.8	4.9	2.0	2.0
	28	17	13.2	12	9	X	9	12	14.7	18	26	29	30
	R		DL						DL				

THIS ILLUSTRATES WHAT IS PRIMARILY A SURFACING PROJECT OVER WIDENING OF EXISTING PAVEMENT. THE TEMPLATE AND GROUNDLINE READINGS WOULD BE ABOUT AS SHOWN. THE ONLY QUANTITIES TO BE DETERMINED ARE EXCAVATION. THE SHOULDERS WILL BE OBTAINED BY BLUE-TOPS AND THE SLOPES BY MACHINERY

PLATE NO. VII-05-05
DATE APRIL 30, 1973

"BORROW PITS"


Cross Sections
Base Line
1
2
3
4
5
6
7
8
Z
W
a b c d e f g h i j v k l m n o p q r s t u
A B C D E F G H I J K L M N P

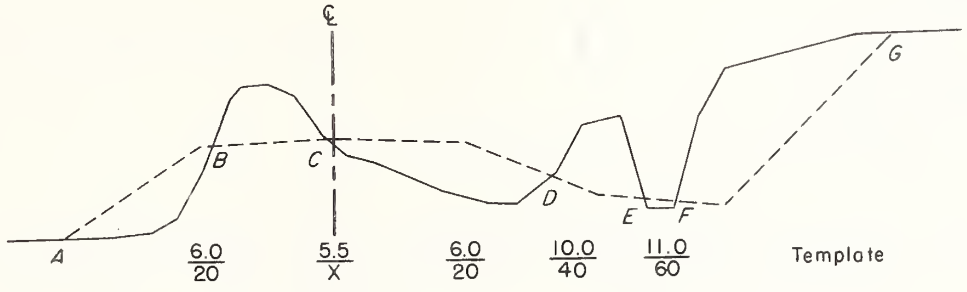
THE MEASUREMENT AND COMPUTATION OF QUANTITIES INVOLVED IN BORROW PITS OR BORROW AREAS CAN BE HANDLED IN VARIOUS MANNERS. THE SAME PROCEDURES CAN BE APPLIED TO STOCKPILES. ONE LINE COMMON TO ALL METHODS IS BASELINE OR CENTERLINE. WHETHER SUCH A LINE TRAVERSES THE APPROXIMATE CENTER OF THE AREA OR IS OFF TO ONE SIDE IS OF MINOR CONSEQUENCE. MOST ENGINEERS PREFER A CENTERLINE OR BASELINE NEAR CENTER. TWO METHODS WILL BE DISCUSSED ON THIS PLATE.

(1) THE ENGINEER ESTIMATES THE BOUNDS OF THE POSSIBLE BORROW AREA, RUNS OUT A CENTERLINE OR BASELINE AS SHOWN ON THE SKETCH, AND DETERMINES THAT CROSS-SECTIONS WILL BE REQUIRED AT VARIOUS PLUSSES DENOTED A, B, C, ETC., N AND P, EACH OF THE LENGTH SHOWN. WHEN THE EXCAVATION IS COMPLETE, HE RETURNS AND RECROSS-SECTIONS ON THE SAME PLUSSES OR LINES AND PROBABLY FINDS IT NECESSARY TO ADD A FEW SECTIONS. HE PROBABLY WOULD VOID THE SECTIONS AT A AND P. HE WOULD, IN THIS CASE, NEED ADDITIONAL SECTIONS AT b, c, e, f, h, i, j, k, n, o, p, q, s and t. HE WOULD HAVE TO INTERPOLATE A GROUNDLINE FOR EACH OF THESE. HE WOULD THEN FIGURE THE END AREA OF EACH SECTION AND FROM THOSE FIGURES DETERMINE THE VOLUME. THIS METHOD HAS BEEN USED FOR MANY YEARS. THE CROSS-SECTIONS HERE WOULD BE THE SAME AS IN ROADWAY CROSS-SECTIONING.

(2) THE ENGINEER ESTIMATES THE BOUNDS OF THE POSSIBLE BORROW AREA, RUNS OUT A CENTERLINE OR BASELINE AS SHOWN ON THE SKETCH, AND DETERMINES THAT CROSS-SECTIONS WILL BE REQUIRED AT VARIOUS PLUSSES DENOTED A, B, C, ETC., N AND P, EACH OF THE LENGTH SHOWN. WHEN THE EXCAVATION IS COMPLETE HE RETURNS AND SIZES UP THE SITUATION. HE NOTES THAT HE WILL NOT HAVE TO REMEASURE TO THE SAME EXTENT HE ORIGINALLY CROSS-SECTIONED BECAUSE THE BOUNDS OF THE PIT ARE LESS THAN HE EXPECTED (REPRESENTED BY LINE W: Z IS THE APPROXIMATE BOTTOM). HE THEN LAYS OUT, ON THE GROUND, THE BOUNDARY LINE "1-2-3-4-5-6-7-8-1". THE BREAKS IN THE BOUNDARY LINE, 2, 3, 4 AND 5, SHOULD BE ON ORIGINAL CROSS-SECTION LINES THAT ARE TO BE REUSED FOR REMEASUREMENT. HE NOTES THAT HE DOES NOT NEED THE PLUSSES AT A AND P. HE NOTES THAT HE WILL NEED CROSS-SECTIONS AT a, b, c, d, e, f, g, h, i, j, v, k, l, m, n, o, p, q, r, s, t, and u TO PROPERLY COMPUTE THE EXCAVATION. HE PROCEEDS TO AMEND THE ORIGINAL GROUNDLINE NOTES BY CROSSING OUT OR CIRCLING THE READINGS BEYOND THE EXTREMITIES OF THE BOUNDARY LINE "1-2-3-4-5-6-7-8-1", AND RECORDING ELEVATIONS WHERE THE LINES C, E, H, I, J AND M INTERSECT THE NEW BOUNDARY LINE; ALSO THE ELEVATIONS AT 1 AND 8 ON LINE B AND 7 AND 6 ON LINE N. THEN HE PROCEEDS TO CROSS-SECTION THE BORROW PIT ON THE LINES NOTED ABOVE, BEING VERY CAREFUL TO TERMINATE EACH SECTION ON THE LINE "1-2-3-4-5-6-7-8-1". HE NOTES A PILE OF WASTED EXCAVATION IN THE CORNER NEAR THE LINE "5-6" WHICH HE ALSO CROSS-SECTIONS ALONG WITH THE EXCAVATION. THE METHOD OF DETERMINATION OF NET QUANTITIES WILL VARY CONSIDERABLY FROM THAT USED IN (1). THIS SYSTEM IS PARTICULARLY ADAPTABLE TO THE ELECTRONIC COMPUTER. A COMPUTER BASE PLANE IS ESTABLISHED A FOOT OR SO ABOVE THE HIGHEST POINT RECORDED IN EITHER ORIGINAL OR REMEASURE NOTES. THEN THE DATA CONCERNING THE ORIGINAL GROUNDLINE IS PROCESSED AND THE VOLUME OF AIR BETWEEN THE BASE PLANE AND ORIGINAL GROUND (LIMITED BY THE LINES "1-2-3-4-5-6-7-8-1") DETERMINED. NEXT, THE REMEASURE DATA IS PROCESSED AND THE VOLUME OF AIR DETERMINED BETWEEN THE BASE PLANE AND THE REMEASURED GROUND (AGAIN LIMITED BY THE LINE "1-2-3-4-5-6-7-8-1"). THE DIFFERENCE IN VOLUMES IS THE NET AMOUNT OF EXCAVATION. THE PILE OF WASTE WILL BE COMPUTED AND DISCOUNTED BUT THE VOLUME WILL NOT BE DISCERNIBLE.

IF THE CONTRACTOR WERE TO EXPAND TO A LARGER AREA THAN ORIGINALLY CONTEMPLATED, THEN THE GROUNDLINE NOTES SHOULD BE EXTENDED ACCORDINGLY. THE FINAL PROCEDURE WOULD BE AS OUTLINED ABOVE.

"OO'S"

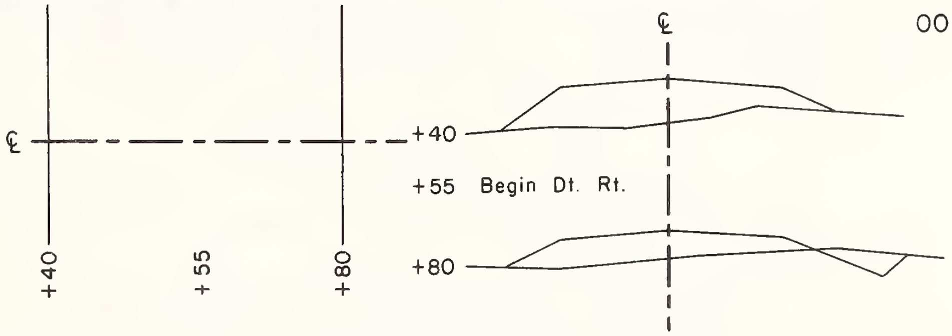


Ground: $\frac{8.0}{20}$ $\frac{2.6}{16}$ $\frac{1.5}{14}$ $\frac{1.3}{10}$ $\frac{2.2}{6}$ $\frac{5.0}{2}$ F0.5 $\frac{6.0}{X}$ $\frac{6.8}{2}$ $\frac{7.3}{6}$ $\frac{9.5}{16}$ $\frac{10.5}{24}$ $\frac{10.6}{28}$ $\frac{8.4}{32}$ $\frac{4.6}{38}$ $\frac{4.0}{44}$

$\frac{11.4}{24}$ $\frac{12.6}{28}$ $\frac{13.0}{36}$ F7.1 $\frac{13.1}{41.3}$ F7.3 $\frac{13.3}{50}$ R   C13.3 $\frac{+2.3}{96}$ R   C13.0 $\frac{+2.0}{86.0}$ $\frac{0.5}{60}$ $\frac{4.0}{56}$ $\frac{11.0}{52}$ $\frac{11.0}{48}$

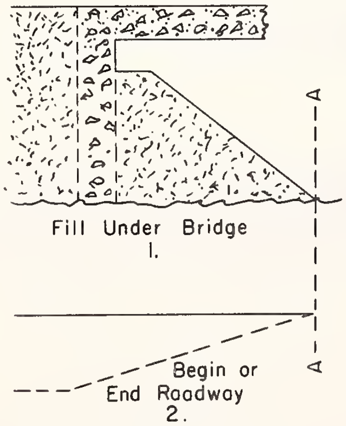
THIS DIAGRAM SHOWS HOW SOME STAKING TIME CAN BE SAVED IF THE ENGINEER IS AUTHORIZED TO TAKE SUCH A SHORT-CUT. IT IS AN ACCEPTED CONTENTION THAT ALL GROUNDLINE BREAKS MUST BE PROPERLY CONSIDERED AND RECORDED IF PROPER QUANTITIES ARE TO BE OBTAINED. THE DIAGRAM SHOWS SEVERAL INTERSECTIONS OF TEMPLATE AND GROUNDLINE. THE RODMAN, UNLESS HIGHLY EXPERIENCED, COULD SPEND CONSIDERABLE TIME IN FINDING THE INTERSECTIONS AT 'B', 'C', 'D', 'E' AND 'F'. WHEN THERE ARE FREQUENT SECTIONS INVOLVED, THE TOTAL TIME CONSUMED IN A DAY WOULD BE QUITE CONSIDERABLE. THE GROUNDLINE SHOWN, OF COURSE, REFLECTS MORE READINGS THAN MOST FOR A NARROW WIDTH. IF THE ENGINEER WERE TO RECORD ALL OF THE BREAKS NECESSARY IN THE GROUNDLINE, ALL OF THE BREAKS IN TEMPLATE, AND THE TWO INTERSECTION POINTS AT 'A' AND 'G', THE ELECTRONIC COMPUTER WOULD FIND ALL OF THE OTHERS DURING THE PROCESS OF AREA DETERMINATION. IT WOULD BE QUITE LIKELY THAT THE ENGINEER WOULD NOT KNOW OF THE TWO "OO'S" AT 'E' AND 'F'. IT IS ABSOLUTELY NECESSARY THAT THE TWO OUTSIDE CATCHS, 'A' & 'G', BE FOUND AND RECORDED IN THE FIELD BECAUSE THESE ARE TEMPLATE DATA AS WELL AS GROUNDLINE DATA. THE COMPUTER WILL MAKE THE ENTIRE AREA DETERMINATION IN ABOUT 15 SECONDS. THE ENGINEER IS CAUTIONED, HOWEVER, THAT IN FOLLOWING THE PRACTICE COVERED ABOVE, HE MUST NOT GET 'SLOPPY' AND MUST PUT IN ENOUGH STAKES ALONG THE ROADWAY TO COVER THE REQUIREMENTS OF GOOD CONSTRUCTION. THIS WOULD BE A VERY ADVANTAGEOUS PROCEDURE WHEN CROSS-SECTIONS ARE CLOSELY SPACED.

OO DITCH



THE ABOVE SKETCHES ILLUSTRATE A TYPICAL SITUATION. THESE SKETCHES INDICATE "BEGIN DITCH RIGHT", THE CONDITION COULD BE "END DITCH RIGHT OR LEFT" OR "BEGIN DITCH LEFT". LET IT BE SUPPOSED, IN THIS CASE, THAT THE DITCH WOULD ACTUALLY BEGIN AT +55 ON THE RIGHT. IT IS NECESSARY TO TAKE A CROSS-SECTION AT +55. AN ENTRY IN THE NOTES "BEGIN DT RT +55" WILL NOT SUFFICE. SEE PLATE VII-05-01.

'OO' SECTION



Also applicable to fills.

(B) THERE ARE OCCASIONS WHEN IT IS NECESSARY TO SHOW THE END OF A FILL OR END OF A CUT WHERE THE END AREA WILL BE ZERO. TWO EXAMPLES ARE SHOWN AT THE LEFT. THE ROD READINGS IN BOTH CASES CAN BE EITHER ACTUAL OR FICTICIOUS--PROBABLY FICTICIOUS UNDER THE BRIDGE. THE STATIONING SHOULD BE ACTUAL. THE DISTANCE FROM CENTERLINE NEED BE NO CLOSER THAN APPROXIMATE--WITHIN 5 FEET IS CLOSE ENOUGH. THE READINGS ON STATION A ARE SHOWN BELOW.

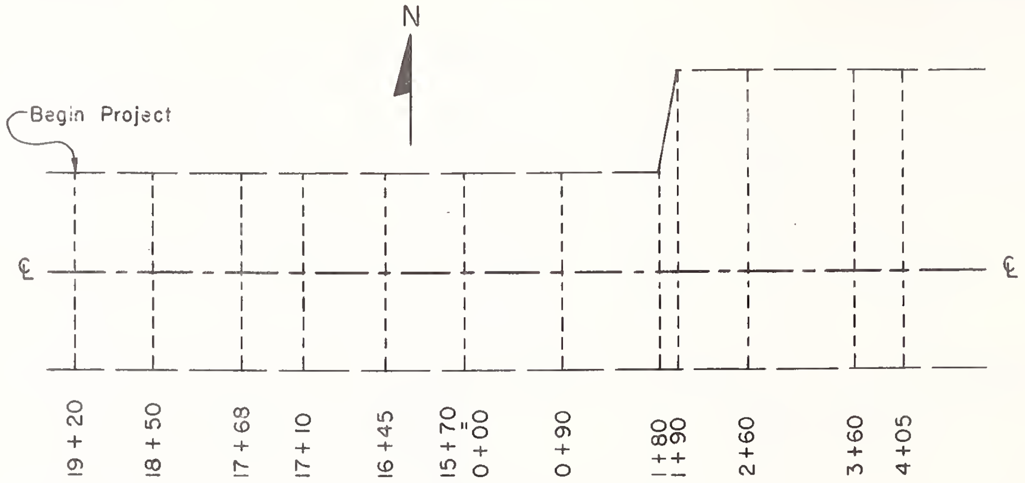
Case 1.	Template	$\frac{5.6}{19}$	$\frac{4.9}{00}$	$\frac{4.7}{19}$
	Groundline	$\frac{5.6}{19}$	$\frac{4.9}{00}$	$\frac{4.7}{19}$
Case 2.	Template	$\frac{3.2}{25}$	$\frac{3.2}{00}$	$\frac{3.2}{25}$
	Groundline	$\frac{3.2}{25}$	$\frac{3.2}{00}$	$\frac{3.2}{25}$

Preceding sections should be taken as conditions require.

DEPARTMENT OF HIGHWAYS — CONSTRUCTION MANUAL

PLATE NO. VII-05-08
DATE APRIL 30, 1973

"MISCELLANEOUS PROBLEMS"



THIS SKETCH IS PREPARED TO REPRESENT SEVERAL SITUATIONS COMMONLY ENCOUNTERED.

1. THE PROJECT BEGINS ON A SURVEY WHICH IS STATIONED FROM EAST TO WEST. THE BEGINNING OF THE STATIONING IS 15+70 WHICH IS EQUAL TO 0+00 ON A SURVEY PROCEEDING FROM WEST TO EAST. CROSS-SECTIONING SHOULD BEGIN AT 19+20 AND RUN EASTWARD THROUGH 18+50, 17+68, 17+10, 16+45, 15+70, 0+00, 0+90, 1+80, ETC., ETC. THEN WHEN THE QUANTITIES ARE WORKED UP THE MASS WILL DEVELOP PROPERLY. THE SAME PROCEDURE WOULD HOLD IF THE STATIONS FROM 19+20 to 15+70 WERE MINUS DISTANCES FROM 0+00, LIKE -3+50, -2+80, -2+08, -1+40, -0+75.

2. THE SURFACING THICKNESS CHANGES 0.8 FT. AT STA. 17+10. THE NOTES WOULD BE RECORDED SOMETHING LIKE THIS:-

H I. 2334.97												
17 + 10 29.00				$\frac{6.4}{20}$		$\frac{60}{X}$		$\frac{6.4}{20}$	$\frac{9.4}{35}$			
	F5.2		F3.9			F1.2		00		C6.0	C2.6	
	$\frac{11.2}{50}$	$\frac{11.2}{33}$	$\frac{10.3}{25.9}$	$\frac{9.3}{18}$	$\frac{7.3}{6}$	$\frac{7.2}{X}$	$\frac{6.9}{7}$	$\frac{6.2}{10}$	$\frac{3.3}{22}$	$\frac{3.4}{47.0}$	$\frac{3.4}{50}$	
	R										R	
				$\frac{7.2}{21.2}$		$\frac{6.8}{X}$		$\frac{7.2}{21.2}$	$\frac{9.4}{35}$			
			F3.1			F0.4	00				C6.0	
17 + 10 28.02	$\frac{11.2}{50}$	$\frac{11.2}{33}$	$\frac{10.3}{25.9}$	$\frac{9.3}{18}$	$\frac{7.3}{6}$	$\frac{7.2}{X}$	$\frac{6.9}{5}$	$\frac{6.9}{7}$	$\frac{6.2}{10}$	$\frac{3.3}{22}$	$\frac{3.4}{47.0}$	$\frac{3.4}{50}$

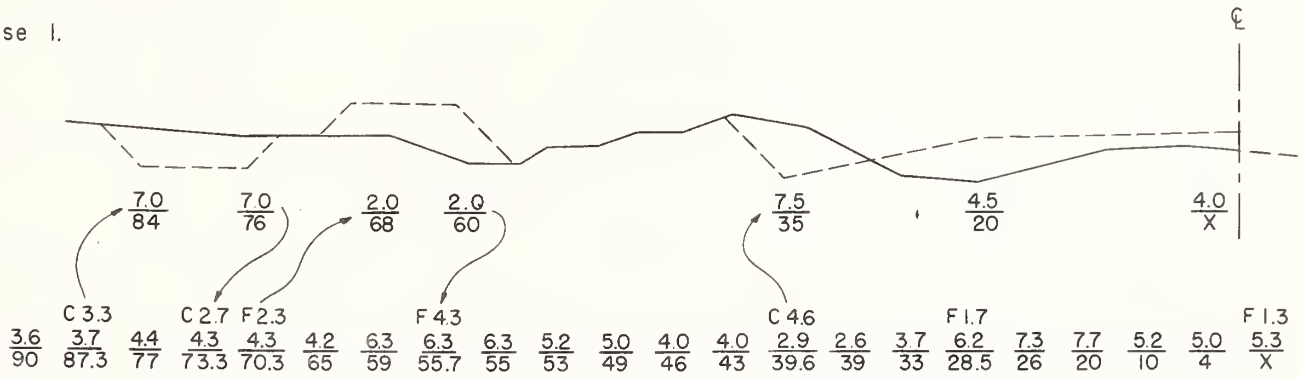
NOTE THAT THE SAME STATION NUMBER IS USED FOR BOTH SECTIONS. THE COMPUTER WILL SUBTRACT THE STATION NUMBER, GET A DISTANCE OF ZERO AND THUS THERE WILL BE NO VOLUME.

3. THE DITCH SECTION IS WIDENED ABRUPTLY AT STATION 1+80--1+90. THE NOTES WOULD BE RECORDED SOMETHING LIKE THIS:

H.I. 2630.00										
1 + 80 26.00				$\frac{8.4}{40}$	$\frac{4.4}{20}$	$\frac{4.0}{X}$	$\frac{4.4}{20}$			
	C1.1		C2.8		F1.4	F1.6			F4.2	F4.7
	$\frac{2.9}{100}$	$\frac{3.6}{70}$	$\frac{5.6}{45.6}$	$\frac{6.0}{42}$	$\frac{5.8}{27.0}$	$\frac{5.6}{X}$	$\frac{6.5}{14}$	$\frac{8.6}{24}$	$\frac{8.6}{26.3}$	$\frac{8.7}{50}$
	R									R
1 + 90 26.00				$\frac{8.4}{85}$	$\frac{4.4}{20}$	$\frac{4.0}{X}$	$\frac{4.4}{20}$			
	C1.1	C5.5			F1.4	F1.6		F4.2		
	$\frac{2.9}{100}$	$\frac{2.9}{96.0}$	$\frac{3.6}{70}$	$\frac{6.0}{42}$	$\frac{5.8}{27.0}$	$\frac{5.6}{X}$	$\frac{6.5}{14}$	$\frac{8.6}{26.3}$	$\frac{8.7}{50}$	
	R								R	

ROADWAY-CHANNEL CHANGE

Case 1.

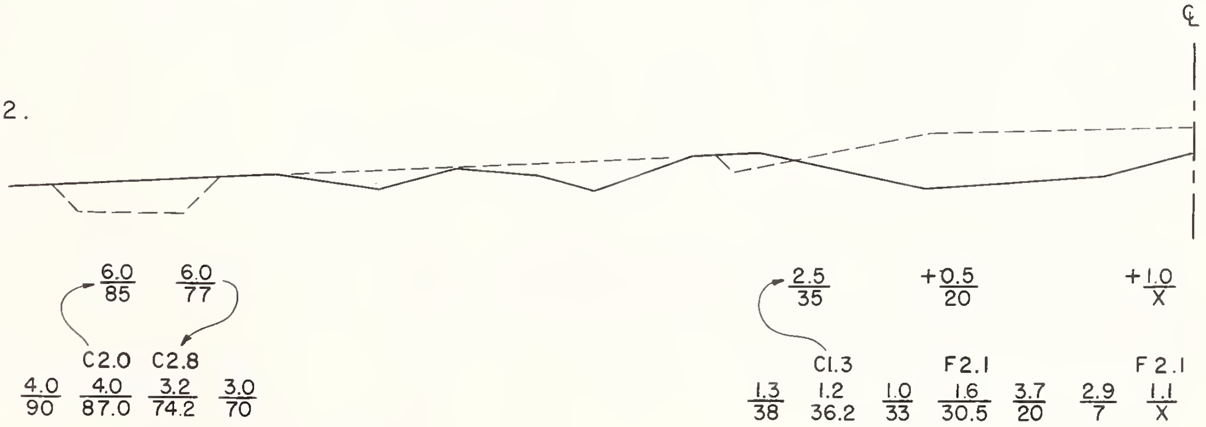


(CASE 1) THIS ILLUSTRATES A CHANNEL CHANGE AND DIKE, WIDELY SEPARATED FROM THE ROADWAY, AND HOW THE NOTES CAN BE RECORDED FOR EASE IN COMPUTER OPERATION. THE TWO SITUATIONS SHOWN ON THIS PLATE ARE THE ONLY ANTICIPATED CASES THAT WILL REQUIRE THE USE OF ARROWS. THE ARROWS CAN BE AVOIDED BY ENTERING IN THE TEMPLATE LINE ALL OF THE INTERSECTIONS OF TEMPLATE AND GROUND FROM 39.6 TO 73.3. IT APPEARS BETTER TO USE THE ARROWS.

THE PUNCH CARD OPERATOR WOULD START THE TEMPLATE READINGS AT 87.3 AND FOLLOW THE ARROWS TO CENTERLINE, AND BEYOND. GROUND WOULD START AT 90 AND BE PUNCHED STRAIGHT THROUGH TO CENTER.

ARROWS MUST POINT FROM LEFT TO RIGHT, REGARDLESS OF WHETHER SECTION IS LEFT OR RIGHT OF CENTERLINE.

Case 2.



(CASE 2) THIS CASE IS SIMILAR TO CASE 1, BUT NO DIKE. IT IS CLEARLY UNDERSTOOD THAT THERE WILL BE NO GRADING DONE BETWEEN 38 AND 70. THE GROUND LINE SHOTS ARE SKIPPED BETWEEN THOSE TWO POINTS. THE TEMPLATE CARD WILL START AT 87.0 AND FOLLOW THE ARROWS TO CENTERLINE, AND BEYOND. THE DASHED LINE BETWEEN 38 AND 70 SHOWS THAT NOTHING WILL BE PUNCHED AS TO TEMPLATE AND GROUND BETWEEN THOSE TWO POINTS. THE SAME PROCEDURES CAN BE APPLIED TO FRONTAGE ROADS.

THERE WILL BE CASES WHERE THE ENGINEER WILL PREFER TO RUN SPECIAL CENTERLINE OR BASE LINE FOR THE CHANNEL CHANGES, ETC.

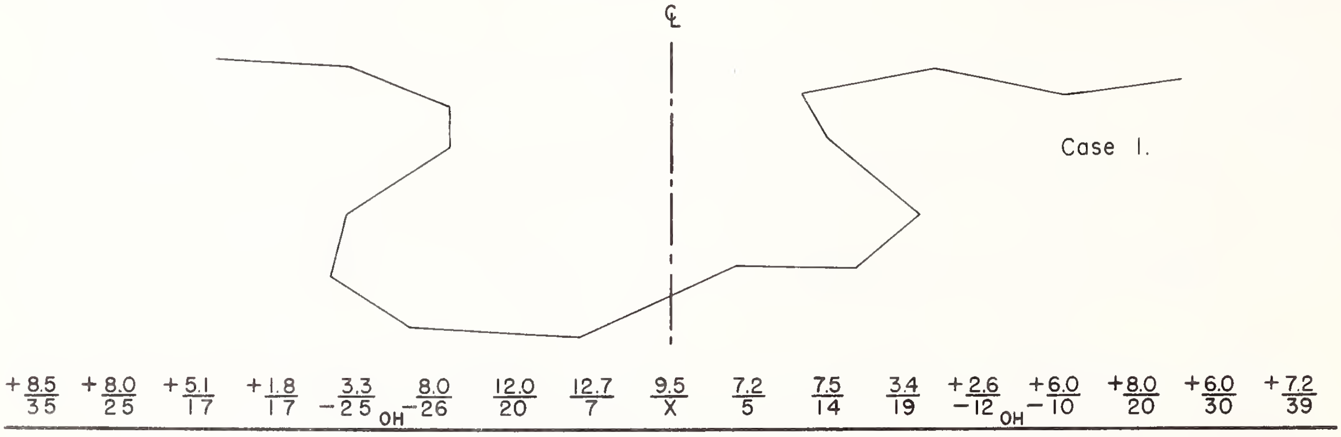
DEPARTMENT OF HIGHWAYS

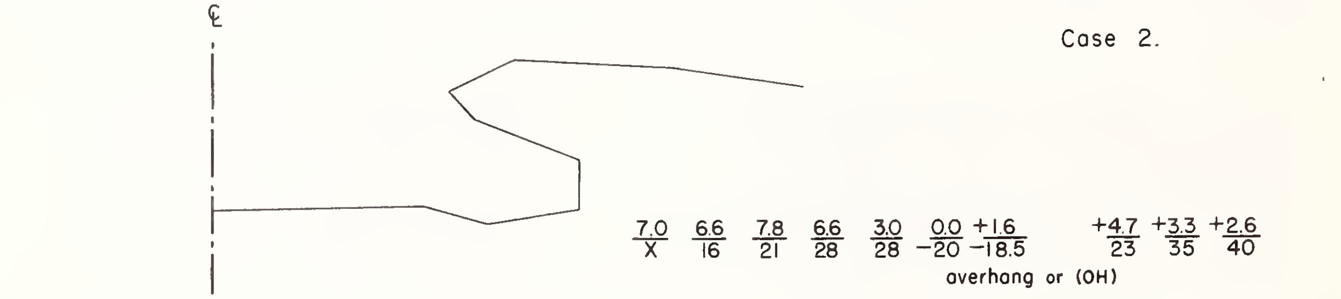
CONSTRUCTION MANUAL

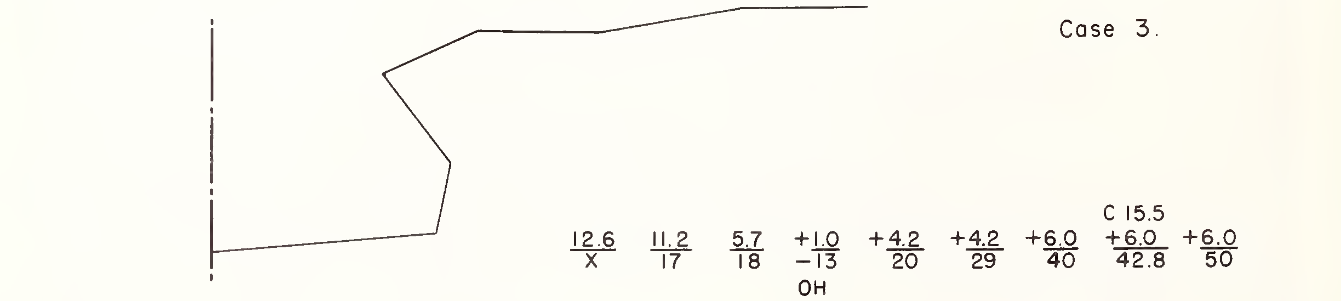
PLATE VII-05-10

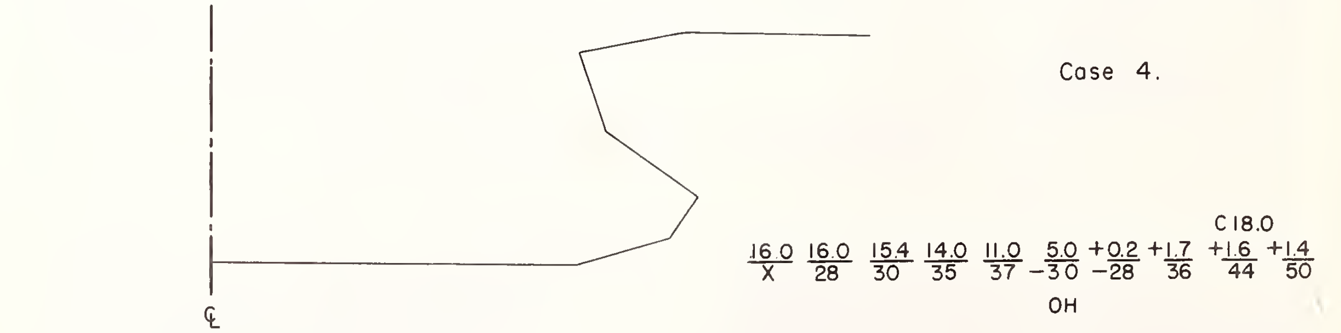
DATE APRIL 30, 1973

OVERHANG


Case 1.


Case 2.

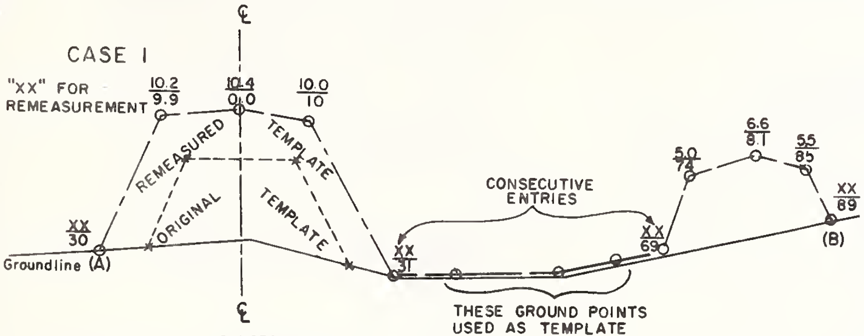

Case 3.


Case 4.

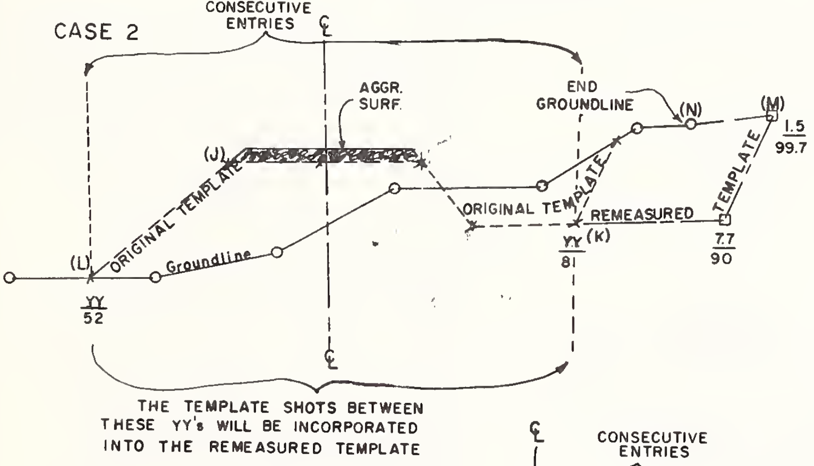
THIS PLATE ILLUSTRATES HOW NOTES SHOULD BE RECORDED WHEN AN OVERHANG OR CAVE IS ENCOUNTERED.

CASE 1 SHOWS AN OVERHANG ON EACH SIDE OF CENTERLINE. THE NOTES SHOW HOW THE GROUND LINE CAN BE RECORDED SO AS TO DETERMINE QUANTITIES. NOTE THE MINUS DISTANCE READINGS AT 25 AND 26 LEFT OF CENTERLINE AND AT 12 AND 10 RIGHT OF CENTERLINE. ANY HORIZONTAL READING THAT REVERSES, READING FROM THE LEFT, BEARS A MINUS SIGN (-25). THE READINGS AT 25 AND 7 ARE PLUS WITHOUT THE SIGN. WHEN THE RIGHT SIDE IS RECORDED, THE MINUS SIGN OCCURS WHEN THE DISTANCE FROM CENTERLINE DECREASES -- THUS 12 AND 10 SHOULD HAVE A MINUS SIGN. THE MINUS SIGN, IN SUCH CASES, INDICATES A REVERSE DIRECTION IN GROUND LINE AND NOTHING ELSE.

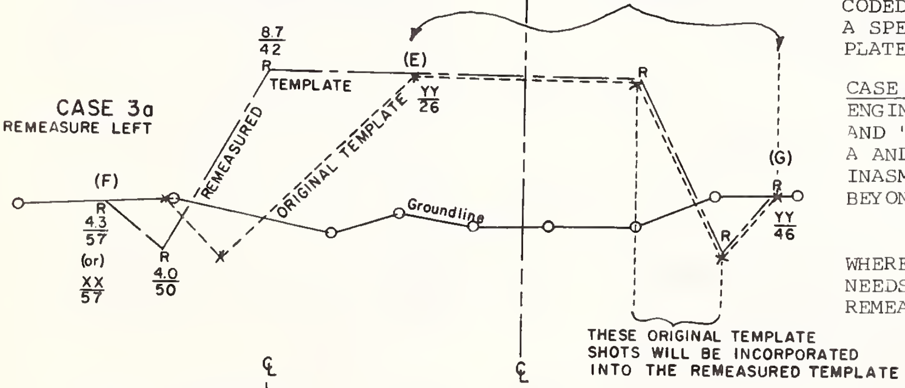
CASE 1



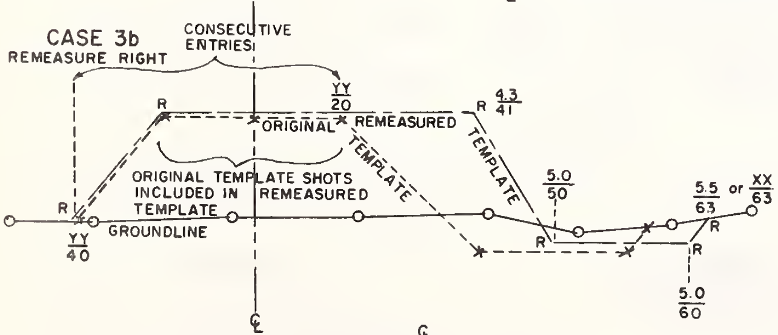
CASE 2



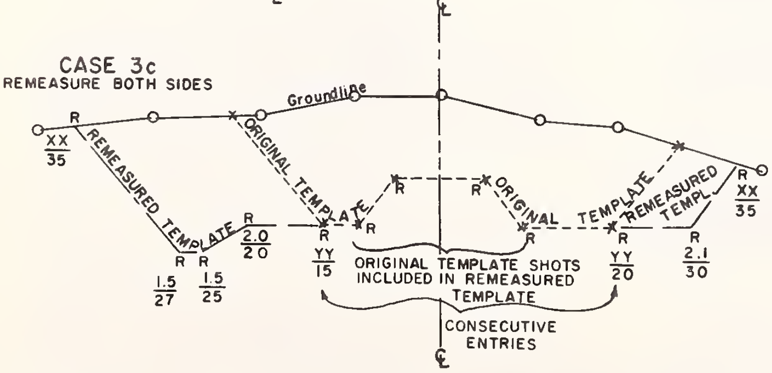
CASE 3a
REMEASURE LEFT



CASE 3b
REMEASURE RIGHT



CASE 3c
REMEASURE BOTH SIDES



REMEASURE

IT WILL BE NECESSARY THAT PARTS OF SOME PROJECTS, AND SOMETIMES ALL, BE REMEASURED IN ORDER TO DETERMINE CORRECT PAY QUANTITIES. IT ALWAYS OCCURS WHEN BORROW PITS ARE USED.

REMEASUREMENT CAN BE CONDUCTED JUST THE SAME AS ORIGINAL CROSS-SECTIONING, ONLY EASIER. IT IS MORE LIKE LOCATION CROSS-SECTIONING. REMEASURE NOTES MUST NOT BE INSERTED INTO THE ORIGINAL GROUNDLINE NOTES.

THE ENGINEER MAY USE ANY H. I. HE WISHES. IT NEED NOT TIE INTO THE CONSTRUCTION STAKING H. I. IT IS NECESSARY, HOWEVER TO REMEASURE AT THE SAME STATIONS AT WHICH CONSTRUCTION STAKING WAS CROSS-SECTIONED. IF IT IS NECESSARY (E.G., ROCK WORK) TO ADD SOME NEW SECTIONS ON REMEASURE THAT WERE NOT IN THE ORIGINAL STAKING, THE FIELD ENGINEER MUST INTERPOLATE THE GROUNDLINE SECTIONS. INTERPOLATED SECTIONS SHOULD BE SUBMITTED AS SUPPLEMENTARY NOTES.

AN "XX" CODED INTO A TEMPLATE SECTION WILL CAUSE THE COMPUTER TO INTERPOLATE AN ELEVATION FROM THE GROUNDLINE DATA AT A CERTAIN DISTANCE. THE USE OF "XX" RODS HAS NO RESTRICTIONS AS TO NUMBER, PLACE, OR ORDER PER SECTION. "XX" MAY BE USED IN EITHER ORIGINAL TEMPLATE NOTES OR REMEASURE NOTES.

A "YY" ROD MAY BE USED IN REMEASURED TEMPLATE NOTES ONLY. "YY" RODS MUST BE CODED IN PAIRS IN ORDER TO INCORPORATE A SPECIFIED PATTERN OF THE ORIGINAL TEMPLATE INTO THE NEW REMEASURED TEMPLATE.

CASE 1. THIS IS A NORMAL CASE WHERE THE ENGINEER ELECTED TO USE DISTANCES ONLY AND "XX" FOR RODS, AT THE CATCH POINTS, A AND B. THIS IS COMPLETELY IN ORDER INASMUCH AS THE GROUNDLINE EXTENDS BEYOND THE REMEASURED SECTION.

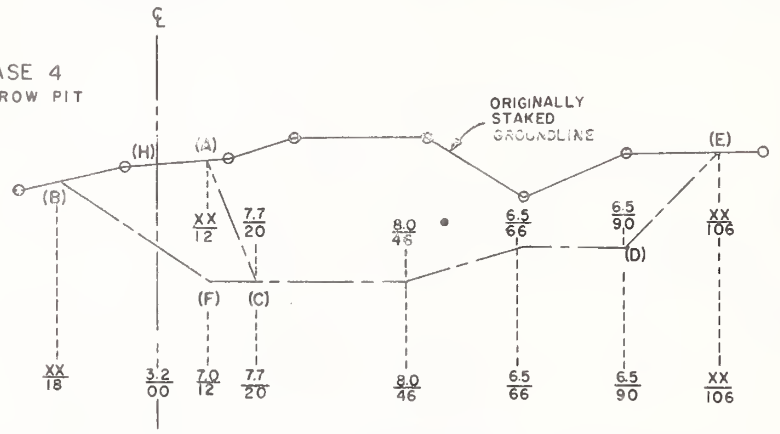
THE LAST SHOT RIGHT AND LEFT, WHERE GROUND AND REMEASURE INTERSECT NEEDS DISTANCE ONLY, PROVIDING THE REMEASURE SECTION IS COINCIDENT WITH AN ORIGINAL GROUNDLINE SECTION AND FURTHER PROVIDING THAT ORIGINAL GROUND NOTES GO FARTHER OUT THAN THE REMEASURE SECTION. IT IS BEST, INSTEAD OF ENTERING A ROD READING, TO WRITE "XX" AS SHOWN.

NOTICE THE TWO CONSECUTIVE "XX" READINGS AT XX/31 AND XX/69. THESE ENTRIES WILL CAUSE THE COMPUTER TO USE THE GROUNDLINE SHOTS BETWEEN THE "XX'S" AS TEMPLATE.

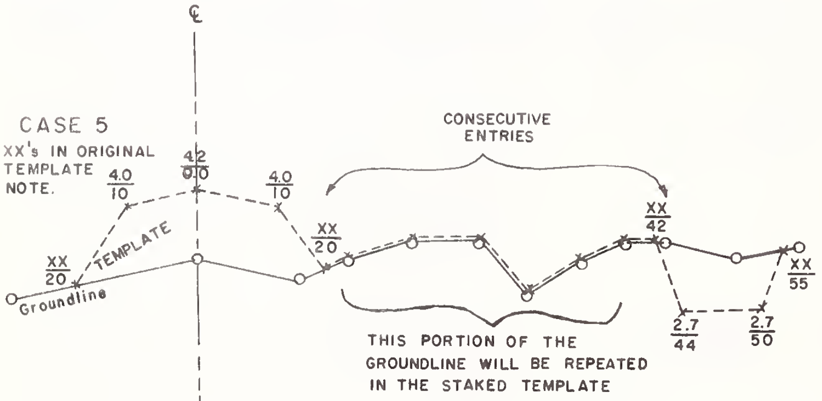
CASE 2. WHEN THE REMEASURE SECTION EXTENDS FARTHER FROM CENTERLINE, EITHER SIDE THAN THE ORIGINAL GROUNDLINE NOTES RECORD, THEN BOTH ROD READING AND DISTANCE ARE NECESSARY AT (M). THE COMPUTER WILL CONNECT POINTS (N) AND (M) AUTOMATICALLY AND DETERMINE THE END AREA. SUCH A READING AS 1.5/99.7 IS NECESSARY. THE USE OF XX/99.7 RESULTS IN NO PROGRESS.

WHEN THE ROADWAY SURFACE IS COVERED WITH GRAVEL (E.G.) AND IS INACCESSIBLE FOR REMEASURE READINGS, THE USE OF "YY" IS ACCEPTABLE, SUCH AS YY/52 AND YY/81 AT (L) AND (K). THE DISTANCE MUST BE THE SAME AS IN THE STAKED TEMPLATE NOTES. THE USE OF "YY" IN THE REMEASURE NOTES WILL TELL THE

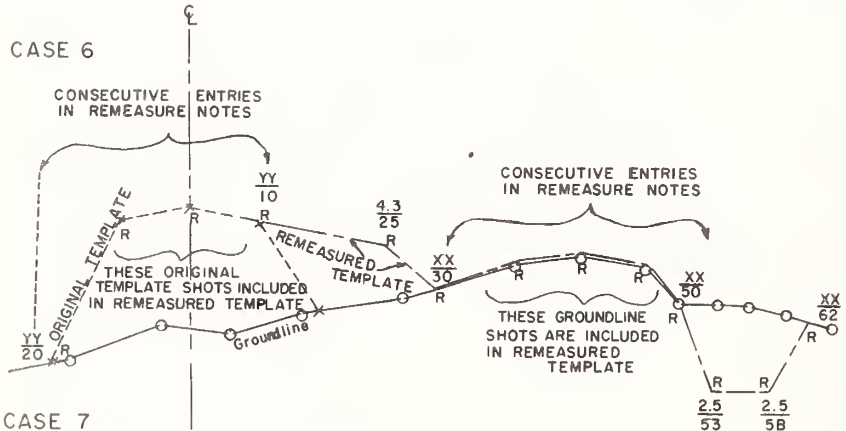
CASE 4
BORROW PIT



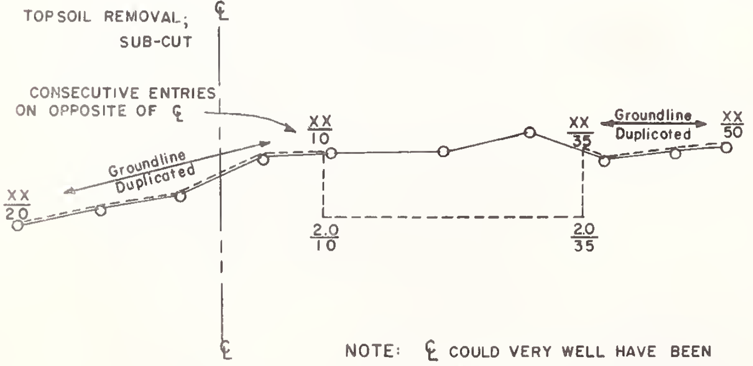
CASE 5
XX's IN ORIGINAL TEMPLATE NOTE.



CASE 6


℄
CONSECUTIVE ENTRIES IN REMEASURE NOTES
YY/10
4.3/25
CONSECUTIVE ENTRIES IN REMEASURE NOTES
ORIGINAL TEMPLATE
REMEASURED TEMPLATE
THESE ORIGINAL TEMPLATE SHOTS INCLUDED IN REMEASURED TEMPLATE
R
XX/30
XX/50
XX/62
THESE GROUNDLINE SHOTS ARE INCLUDED IN REMEASURED TEMPLATE
Groundline
YY/20
2.5/53
2.5/58

CASE 7
TOPSOIL REMOVAL;
SUB-CUT



NOTE: ℄ COULD VERY WELL HAVE BEEN LOCATED IN THE SUBCUT. IN THAT CASE XX LOCATION AND USE WOULD BE SIMILAR TO PREVIOUS CASES.

COMPUTER TO USE THE STAKED TEMPLATE NOTES BEGINNING WITH THE FIRST "YY" AND ENDING WITH THE NEXT "YY". (BEGIN YY/52, END YY/81). ALL ACTUAL REMEASURE READINGS (ROD/DISTANCE OR XX/DISTANCE) MUST BE FARTHER FROM CENTERLINE, EITHER SIDE, THAN A "YY" READING.

THE USE OF YY READINGS IS NOT PERMISSIBLE IF THE FINISHED ROADWAY IS NOT IN CONFORMITY TO THE ORIGINAL TEMPLATE.

CASE 3 - A. B. & C. THIS ILLUSTRATES ANOTHER SITUATION THAT COULD HAPPEN ON EITHER SIDE OF CENTERLINE. THE LEFT SIDE, CASE 3-A, NEEDS REMEASURE BUT THE RIGHT SIDE DOES NOT, BECAUSE IT WAS CONSTRUCTED IN CONFORMITY TO THE ORIGINAL TEMPLATE. THIS IS INDICATED BY THE SUGGESTED TYPICAL NOTES. LIKEWISE THE READING AT (F) COULD BE XX/57 INSTEAD OF 4.3/57. CASE 3-B, IS SIMILAR TO CASE 3-A. REMEASURE IS REQUIRED ONLY ON THE RIGHT SIDE. CASE 3-C, ILLUSTRATES REMEASURE ON BOTH SIDES OF CENTERLINE.

CASE 4. THIS ILLUSTRATES A BORROW PIT THAT WAS ORIGINALLY CROSS-SECTIONED ON BOTH SIDES OF A BASELINE OR CENTERLINE. WHEN EXCAVATION WAS COMPLETED, THE REMEASURE SECTION LOOKED LIKE ACDE. "XX" CAN BE USED AT (E), XX/106 AND AT (A), XX/12.

IF THE REMEASURED SECTION WERE REPRESENTED BY BFCDE, THEN "XX" COULD HAVE BEEN USED AT (B), AS XX/18 or 4.0/18, AS THE ENGINEER DECIDES.

CASE 5. THIS ILLUSTRATES THE USE OF "XX'S" IN THE ORIGINAL TEMPLATE NOTES. NOTICE THAT "XX'S" ARE CONSECUTIVE ENTRIES AND ARE BOTH ON THE SAME SIDE OF CENTERLINE.

CASE 6. IS AN EXAMPLE OF THE JOINT USE OF "XX" AND "YY".

CASE 7. SHOWS THE USE OF "XX" FOR TOPSOIL REMOVAL, SUB-CUT, ETC.

NOTE: ONLY THOSE ENTRIES SHOWN ON THE EXAMPLE DRAWINGS (CASES 1-7) HAVE TO BE INCLUDED IN THE ENGINEER'S ACTUAL NOTES.

REMEMBER

1. "XX" MAY BE USED AS A ROD READING ANYWHERE ON THE SECTION.
2. "XX'S" MAY BE RECORDED CONSECUTIVELY IN THE CROSS-SECTION NOTES.
3. "XX" CAN BE USED ANY NUMBER OF TIMES ON THE SAME SIDE OF CENTERLINE PER SECTION.
4. "YY" CAN BE RECORDED IN REMEASURED TEMPLATE NOTES ONLY.
5. "YY'S" MAY BE CODED IN PAIRS ONLY.
6. "YY" MAY LIE ANYWHERE ON THE STAKED TEMPLATE AS LONG AS IT IS USED ONLY ONCE ON THE SAME SIDE OF CENTERLINE.

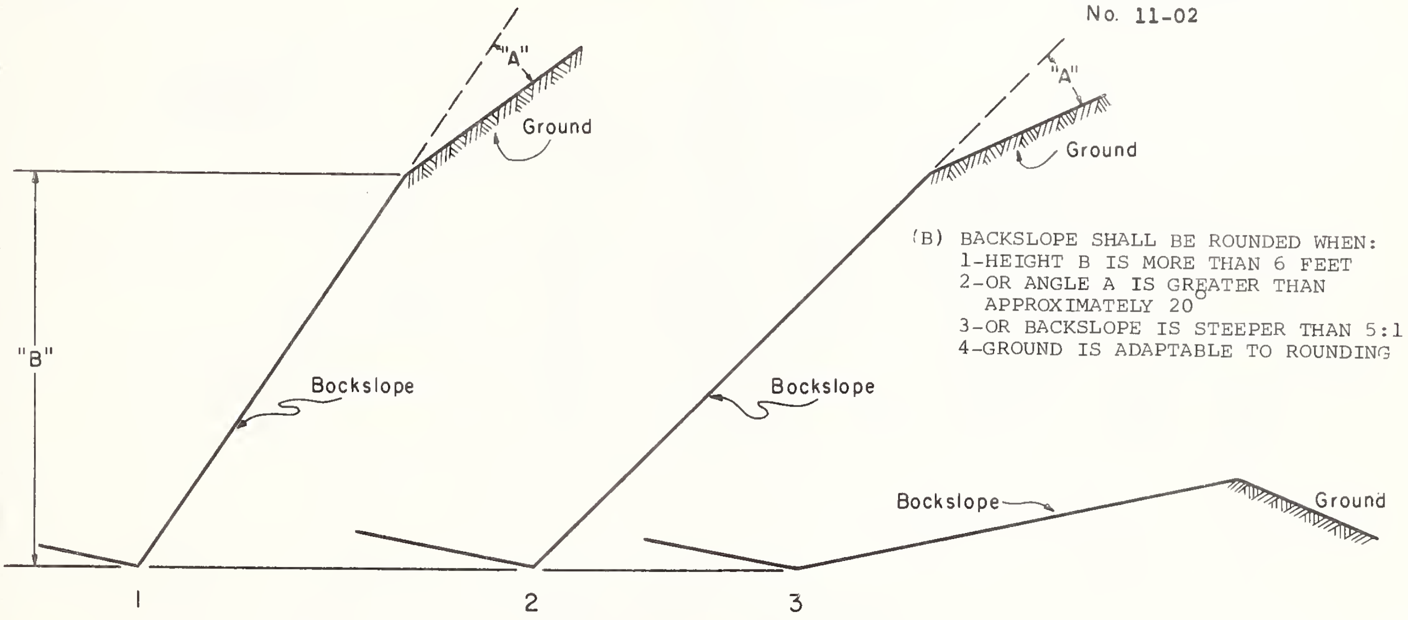
DEPARTMENT OF HIGHWAYS

CONSTRUCTION MANUAL
PLATE NO. VII - 05 - 12
DATE APRIL 30, 1973

SAMPLE CONDITIONS

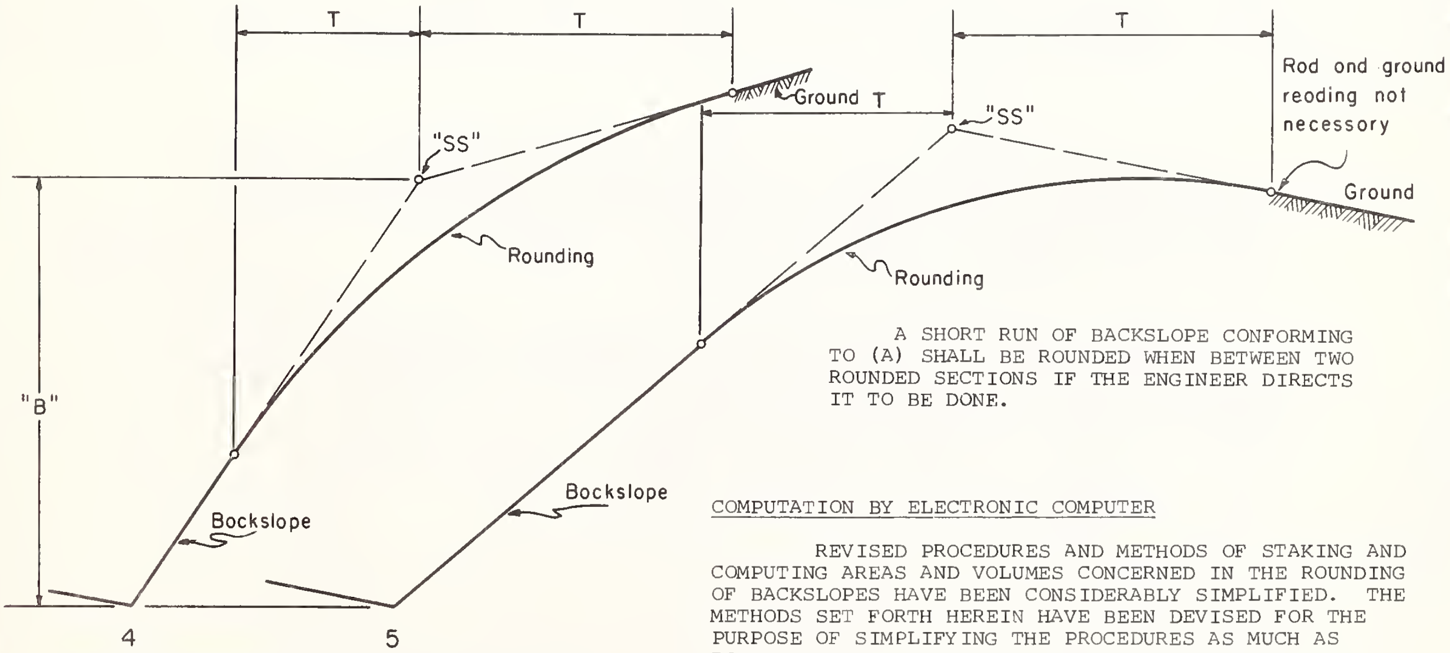
"BACKSLOPE ROUNDING"

See Standard Drawing
No. 11-02



(B) BACKSLOPE SHALL BE ROUNDED WHEN:
1-HEIGHT B IS MORE THAN 6 FEET
2-OR ANGLE A IS GREATER THAN APPROXIMATELY 20°
3-OR BACKSLOPE IS STEEPER THAN 5:1
4-GROUND IS ADAPTABLE TO ROUNDING

(A) BACKSLOPE SHALL NOT BE ROUNDED WHEN:
1-HEIGHT B IS 6 FEET OR LESS
2-OR ANGLE A IS LESS THAN APPROXIMATELY 20°
3-OR BACKSLOPE IS 5:1 OR FLATTER
4-OR NATURAL SOIL IS ROCK, HEAVY GRAVEL OR OTHERWISE UNADAPTABLE



A SHORT RUN OF BACKSLOPE CONFORMING TO (A) SHALL BE ROUNDED WHEN BETWEEN TWO ROUNDED SECTIONS IF THE ENGINEER DIRECTS IT TO BE DONE.

WHEN ROUNDING AREAS ARE COMPUTED BY THE ELECTRONIC COMPUTER, THE PROGRAM IS SO ARRANGED THAT, IF THE DISTANCE FROM THE SLOPE STAKE (SS) TO THE FARTHEST READING FROM CENTERLINE IS LESS THAN T DIST., THE EXTENT OF ROUNDING WILL BE LIMITED TO THAT DISTANCE (E.G.--SS TO LAST SHOT = 3', ROUNDING WILL BE 3 x 3).

IT IS NOT NECESSARY, AS FAR AS AREA COMPUTATIONS ARE CONCERNED, TO TAKE A ROD AND GROUND READING AT THE OUTSIDE EXTENT OF ROUNDING.

THE ENGINEER WILL STAKE BEGINNING AND ENDING OF EACH SECTION OF ROUNDING, WITH LATH OR STAKES OR OTHER SUITABLE MEANS, FOR THE CONTRACTOR"S GUIDANCE.

COMPUTATION BY ELECTRONIC COMPUTER

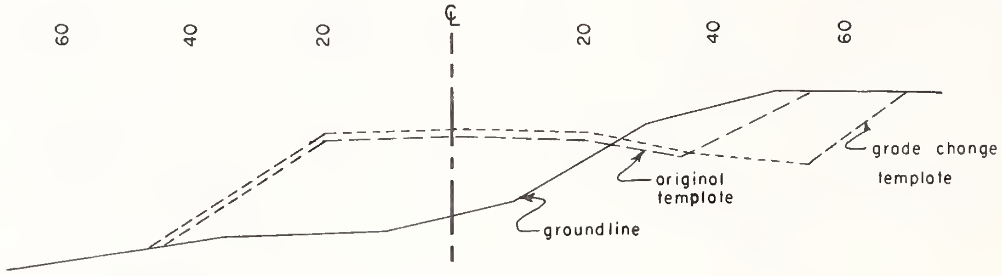
REVISED PROCEDURES AND METHODS OF STAKING AND COMPUTING AREAS AND VOLUMES CONCERNED IN THE ROUNDING OF BACKSLOPES HAVE BEEN CONSIDERABLY SIMPLIFIED. THE METHODS SET FORTH HEREIN HAVE BEEN DEVISED FOR THE PURPOSE OF SIMPLIFYING THE PROCEDURES AS MUCH AS POSSIBLE, AS FAR AS THE ENGINEER IS CONCERNED. ONE CASE WHERE ROUNDING WOULD NOT BE REQUIRED OR PERFORMED, NOT SHOWN HEREON, IS THAT OF INSUFFICIENT RIGHT-OF-WAY WIDTH. THE COMPUTER WILL COMPUTE ROUNDING QUANTITIES IN ACCORDANCE WITH THE DESIGN SHOWN HEREON.

IT IS NOT NECESSARY TO TAKE A READING AT A POINT "T" DIST., BEYOND THE SLOPE STAKE JUST BECAUSE OF ROUNDING. THE COMPUTER WILL MAKE THE COMPUTATION WITHOUT THAT IF THERE IS A READING BEYOND THE SLOPE STAKE -- IT SHOULD BE AT LEAST TEN FEET, IF POSSIBLE.

IF THE ENGINEER WANTS ROUNDING QUANTITIES COMPUTED, HE MUST SAY SO IN HIS LETTER OF TRANSMITTAL; OTHERWISE THE COMPUTATION WILL NOT BE MADE. IF THERE ARE ANY EXCEPTIONS, LIKE STATION XX TO STATION YY, LEFT OR RIGHT, HE MUST SO STATE.

Rev. 5-1-73

GRADE CHANGE



Sample original staking notes.

Template				$\frac{10.4}{20}$		$\frac{10.0}{0}$		$\frac{10.4}{20}$			$\frac{13.4}{35}$		
Ground	$\frac{30.3}{68}$ R.P.	F16.6 $\frac{27.0}{44.9}$ 1½:1	$\frac{25.5}{35}$		$\frac{24.5}{10}$	F12.2 $\frac{22.2}{0}$	$\frac{20.0}{10}$		F1.2 $\frac{11.6}{26.0}$	$\frac{8.5}{30}$		$\frac{3.4}{50}$	C10.0 $\frac{3.4}{55.0}$ 2:1	$\frac{3.4}{76}$ R.P.

SAMPLE GRADE-CHANGE NOTES

USE THE FOLLOWING PROCEDURE ONLY WHEN GROUNDLINE NOTES HAVE ALREADY BEEN PUNCHED

TEMPLATE	F18.0 $\frac{27.4}{47.0}$ 1½:1	$\frac{9.4}{20}$	$\frac{9.0}{0}$	$\frac{9.4}{20}$	$\frac{12.4}{35}$	$\frac{14.4}{55}$	C11.0 $\frac{3.4}{71.5}$ 1½:1

THIS ILLUSTRATES THE ENTRY OF THE TEMPLATE NOTES, AND THESE ONLY, IN AND ON ENTIRELY DIFFERENT PAGES OF THE NOTEBOOK. THE GROUNDLINE NOTES ARE NOT AMENDED IN ANY WAY. THE SLOPE STAKE READINGS FOR THE TWO OUTSIDE CATCHES ARE ENTERED INTO THE TEMPLATE BLOCK RATHER THAN INTO THE GROUNDLINE BLOCK. THE INSIDE CATCH AT 26.0' RIGHT COULD BE ENTERED INTO THE NEW TEMPLATE NOTES, BETWEEN 20' AND 35' RIGHT, IF THE ENGINEER SO DESIRES.

NOTATION MUST BE MADE, IN THE ORIGINAL NOTES, THAT A GRADE CHANGE HAS BEEN MADE.

THE NEW TEMPLATE NOTES MUST BE PROPERLY IDENTIFIED AND SUPPLEMENTED BY SUCH INFORMATION AS STATION, GRADE, H.I., AND ANY OTHER PERTINENT DATA. ANY H.I. MAY BE USED FOR THE REVISED TEMPLATE SINCE THE MACHINE WORKS WITH TRUE ELEVATIONS. THE SAME H.I. WAS USED HERE FOR EASE OF COMPARISON ONLY.

IF REVISED QUANTITIES ARE REQUIRED, SEND THE NEW NOTES TO HELENA FOR COMPUTATION. THEY WILL BE BLENDED WITH THE ORIGINAL NOTES.

STATE OF MONTANA
DEPARTMENT OF HIGHWAYS
EQUATIONS AND BRIDGES

30-180

DPS E-10-C

× IDENT. NO.	
1 … 5	1 0 (6 7)

Project No.__________ Coded By__________

Date__________

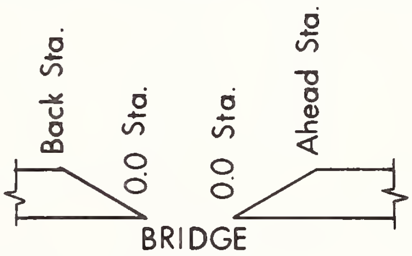
Data Checked By__________

EQUATIONS

* 8	Back Station 9 … 16	* 17	Ahead Station 18 … 25	Line
	+		+	
	+		+	
	+		+	
	+		+	
	+		+	
	+		+	
	+		+	
	+		+	

EQUATIONS

* 8	Back Station 9 … 16	* 17	Ahead Station 18 … 25	Line
	+		+	
	+		+	
	+		+	
	+		+	
	+		+	
	+		+	
	+		+	
	+		+	



× IDENT. NO	
1 … 5	1 1 (6 7)

Bridge or Begin And End Stations

* 8	Back Station Toe 9 … 16	* 17	Ahead Station Toe 18 … 25	Line
	+		+	
	+		+	
	+		+	
	+		+	
	+		+	
	+		+	
	+		+	
	+		+	

* 8	Back Station Toe 9 … 16	* 17	Ahead Station Toe 18 … 25	Line
	+		+	
	+		+	
	+		+	
	+		+	
	+		+	
	+		+	
	+		+	
	+		+	

* All Equations Require A Cross-section

× By Data Processing Section

Rev. 5-1-73

STATE OF MONTANA
DEPARTMENT OF HIGHWAYS

BACKSLOPE ROUNDING

× IDENT. NO.	
1 … 5	1 5 6 7

Project No. ________________ Coded By ________________

Data Checked By ________________ Date ________________

* 8	FROM STATION 9 … 16	* 17	TO STATION … 25	L or R 26 27	LINE 79 80
	+		+		
	+		+		
	+		+		
	+		+		
	+		+		
	+		+		
	+		+		
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	+		+		
	+		+		
	+		+		
	+		+		

* All Equations Require A Cross-section
× By Data Processing Section Only

NOTE: Code A "-1", "0", or "1" in Column 27
TO SPECIFY RND'G LEFT, BOTH, OR RIGHT.
UP TO 60 RND'G CARDS MAY BE CODED.

30-18Q DPS 17-C

STATE OF MONTANA
DEPARTMENT OF HIGHWAYS
HELENA, MONTANA

CONSTRUCTION DATA TRANSMITTAL SHEET

For Data Processing
Submit In Duplicate

Project No. ______________________

Designation ______________________

Mgr. F.P.U. ______________________

Date ______________________

By Data Processing Section Only

Recd. DPS	Compl. DPS

Are notes being submitted for this processing ? ☐ Yes ☐ No

What type ? ☐ Original ☐ Remeasure ☐ Extensions

☐ Other ______________________

____

____

CODE SHEETS SUBMITTED

(List the code sheets by Form No and give the total number of sheets submitted)

DPS FORM NO.	NO. OF SHEETS

Total no of sheets ______________________

Type of computation requested : ☐ Areas & Volumes ☐ Emb + ☐ Mass

☐ Station Yards ☐ Backslope Rounding Remarks ______________________

____

Area No.	Class	Project	Agree	Unit	Work	Control	Comm
						9402	177

Rev. 5-1-73

30-18R DPS-E40-C

STATE OF MONTANA
DEPARTMENT OF HIGHWAYS

Project No.__________ Coded By__________ Data Checked By__________ Date__________

COMPACTION FACTORS

× IDENT. NO. 1 … 5	6 7
	4 0

BALANCE POINTS

× IDENT. NO. 1 … 5	6 7
	4 1

CODE TO COLUMN 16 ONLY.

* 8	STATION 9 … 16	17	CODE 18	FACTOR 19 … 24	STANDARD FACTOR TABLE 1.45 25 … 27	1.35 28 … 30	1.25 31 … 33	1.15 34 … 36	1.10 37 … 39	LINE 79 80
	+									
	+									
	+									
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* All Equations Require A Cross section
× By Data Processing Section Only

Rev. 5-1-73

COLUMN 18 CODING: (COMPACTION CARDS ONLY)
STANDARD FACTORS
ADJUSTED STANDARD (CODE ADJ. IN COLS. 19-24)
MODIFIED TABLE (CODE NEW TABLE IN COLS. 25-39)
CONSTANT FACTOR (CODE FACTOR IN COLS. 19-24

DPS-E42-C

STATE OF MONTANA
DEPARTMENT OF HIGHWAYS

ADDED QUANTITIES

Note: Forced Balance Run Only.
NF (Col. 33) Usually blank or Zero.
Code NF = 1 if Admass has already been factored.

× IDENT.NO 1–5	6–7
	4 2

Project No ______ Coded By ______ Data Checked By ______ Date ______

* 8	STATION 9–16	CUT 17–24	FILL 25–32	NF 33	HAUL DISTANCE 34–38	REMARKS 39–71	LINE 79–80
	+						
	+						
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	+						

* All Equations Require A Cross-section
× By Data Processing Section Only

Rev. 5-1-73

30.08 Precision, Accuracy, and Tolerances

In general the accuracy of horizontal and vertical controls is to conform to recognized standards for accuracy, with the degree of accuracy consistent with the intended use.

A. Vertical Control

The error of closure in establishing or checking bench marks is to be mo more than 0.02 of a foot. An error of closure on the bench mark of 0.05 of a foot is allowable for such level work as taking cross-sections, setting grade stakes, and slope staking.

The accuracy of reading the level rod should be as shown below for the type of work intended.

1. 0.01 of a foot for setting grade for forms, structure, pavements, curbs, gutters, walls, rails, etc.

2. 0.05 of a foot when setting subgrade stakes (bluetops).

3. 0.1 of a foot when reading ground elevations for cross sectioning and setting of slope stakes.

B. Horizontal Control

If measurements are to be consistent, it is evident that the accuracy of angles should correspond with the accuracy of the related distances. Therefore, the percentage of angular error should equal the percentage of error in distance, whenever this equality is practical. The ratio of linear error in highway work should be equivalent to third order surveying. This is one foot in five thousand feet. The angular error should also correspond to third order work. The following table shows ratios of accuracy from one foot in 344 feet to one foot in 206,000 feet. The various angular errors corresponding to ratios of accuracy are determined for a length of 1,000 feet. For a length other than 1,000 feet the linear error is in direct proportion to the angular error. An example illustrating the use of this table is as follows: Assume that distances are to be chained with an accuracy of 1 in 5,000; the corresponding permissible angular error would then be 30 seconds.

Angular Error	Linear Error in 1,000 Ft.	Ratio of Accuracy
10' 00"	2.9089	1/344
04' 00"	1.4544	1/688
01' 00"	0.2909	1/3,440
30"	0.1454	1/6,880
20"	0.0970	1/10,300
10"	0.0485	1/20,600
05"	0.0242	1/41,200
01"	0.00484	1/206,600

Table II-1

In most of the survey work done the distances are accurately determined to the proper accuracy whereas angles are measured more or less to the desired accuracy without increased loss of time or effort.

The standard steel tape "chain" is manufactured to provide accurate measurements of 100 feet when the air temperature is 68° Fahrenheit and when the chain is supported or pulled to the specified tension. The magnitude of changing length is related to the coefficient of thermal expansion. The coefficient of expansion for a steel tape is 0.00000645 feet per foot for each degree above or below 68° Fahrenheit. The change in length of the tape from the standardized temperature of 68° Fahrenheit can be easily calculated from the following formula. The table below may also be used:

$l = L + Lct$

Where l = change in length of steel tape

L = full length of steel tape, usually 100'

c = coefficient of expansion, 0.00000645

t = difference between 68° F. and temperature of the tape

The following table has been included for ease of computing temperature corrections. The general roadway survey will not require temperature corrections; however, each engineer should compare the daily temperatures with the work he is doing and the accuracy required for that work before he chooses not to use a temperature correction.

TABLE OF TEMPERATURE CORRECTION

For 100 Ft. Steel Tape Standardized at 68° F.

Chain has shortened	
-30°	0.0631
-25°	0.0599
-20°	0.0568
-15°	0.0536
-10°	0.0503
- 5°	0.0471
0°	0.0439
5°	0.0407
10°	0.0374
15°	0.0342
20°	0.0310
25°	0.0277
30°	0.0245
35°	0.0213
40°	0.0181
45°	0.0148
50°	0.0116
55°	0.0084
60°	0.0052
65°	0.0019
68°	0.0000

Chain has lengthened	
68°	0.0000
70°	0.0013
75°	0.0045
80°	0.0077
85°	0.0110
90°	0.0142
95°	0.0174
100°	0.0206
105°	0.0239
110°	0.0271

Note: When measuring between two established points, add temperature corrections above 68° F. to measured distance and subtract below 68° F.

When laying out a given distance, subtract temperature correction above 68° F. and add below 68° F.

Table III-2

Errors caused by excessive sag can be compensated for by duplicating the pull or tension at which the tape was standardized, usually about 10 pounds, with the tape supported for its full length.

30.09 Land and U.S. Survey Monuments

Highway construction frequently cuts through or fills areas containing section corners, subdivision corners, U.S. bench marks, or other similar monuments. Engineers should take steps to preserve all existing corners during construction and to set permanent markers or witness markers after the work is completed. Monuments, corners, and similar survey points should be thoroughly and completely protected during the course of construction operations. Steps should be taken by the engineer to preserve or reset all U.S.C. & G.S., B.L.M., or other agency bench marks, triangulation points, land monuments, and all permanent markers found on the project.

The plans should be examined for location of section lines, or subdivision lines, crossing or intersecting other lines within the limits of the right-of-way. The plans may indicate the location of land monuments. Notations should be made in field notebooks of the indicated monuments and land line intersections so the locations may be investigated for existing monuments.

Most counties in Montana do not have a county surveyor or county engineer; however, for those counties that do, the county surveyor should be asked to witness the referencing in preparation for resetting a section corner or similar land monuments. Only the Judge can establish a section corner, but the engineer can perform the survey and must have these notes properly recorded in the Court House. Referencing of land monuments should include at least three substantial tie points, sufficiently removed so there is no chance of their being destroyed during construction operations. When no monument is visible, investigation should be made to determine positively that it is not buried. Monuments to be re-established in gravel roads should be set about 6 inches below the finished grade. A metal marker such as a railroad spike should be inserted flush with the surface of pavement on paved roads, and a cross chiseled or filed on its top to show the center of the monument. Careful notes should be kept of the references, which include description of corners found and referenced. The notes should be witnessed by the signatures of two or more persons. A record is to be filed with the County Clerk & Recorder as soon as monuments have been set.

U.S.G.S. Monuments: The U.S. Geological Survey Monuments may serve as a level monument or a transverse monument; or one monument may contain both level and transverse information. Notify the United States Department of the Interior, Geological Survey, in the event that it is necessary to move one of their monuments. The notification should give the general description of the area in which the monument is located and the description stamped on the bronze plate. The U.S.G.S. will then either send a party to move it, or send forms on which to enter a description of the new location and field notes for revision of the data. The accuracy of level monuments should be preserved by recording the difference in elevation from the old location to the reset location in thousandths of a foot: The true bearing of traverse monuments to be reset should be determined to the nearest one-half degree with the horizontal distance to the nearest one-tenth of a foot from the old to the new location. Where the true bearing is not available, reference the monument accurately so the exact location can be re-established. Send this information to the U.S.G.S.. They can then reset the monument with their own forces.

U.S. Coast and Geodetic Monuments: When a U.S.C. and G.S. monument is found, and will be disturbed by construction, immediately notify the Director, Coast and Geodetic Survey, U.S. Department of Commerce, Washington 25, D.C., by letter. Send a copy of this letter to the U.S. Department of the Interior, Geological Survey, and a copy to the Division Office. The letter should state the reason for wanting to move the monument, a general description of the area in which it is located, the designation stamped on the bronze plate and contain a pencil rubbing of the plate. If it is urgent that the monument be moved at once, request a hurried reply to the letter. Full instructions will be sent for resetting the monument. After the monument is reset, send the requested data to the U.S.C. & G.S. office.

30.10 Survey Notes - General

All field notes should be recorded on standard field notebook paper which is available by requisition from the Division office.

The construction survey notes cover alignment, bench marks, cross section, grade stakes, slope stakes, stakes set for structures, and miscellaneous construction survey data. Survey entries should be the original entry. They are not to be taken on scratch paper for copying at a later date. All notes shall show the name of the person making the notes, the person doing the checking, the date for each day, the party personnel, and weather information. Symbols may be used to designate the person running the instrument, doing the chaining, rodding work, or other survey duties.

Each notebook should be identified on the front cover by subject, alignment, cross sections, etc. project number and the name of the Project Manager. On small projects some of the separate operations and miscellaneous survey notes may be combined in a single notebook, whereas larger projects may require separate notebooks for each operation. Notebooks that contain many different types of survey data should contain an index in the front page stating the book's contents.

Notes should be legible and recorded so that other engineers may readily interpret any part. Avoid erasures, make revisions or deletions by crossing through the deleted part and placing the correct entry near by.

The transit book should contain complete information of the constructed center line or other lines run, reference for control points, and any errors found in angles or chain and the corrections made thereto.

Check levels should be run on existing bench marks. If errors are found, corrections should be made and new descriptions for the bench marks established and recorded in the level book with the proper cross referencing to the original level data. Bench marks that will be disturbed during construction must be replaced outside construction limits and the proper records made.

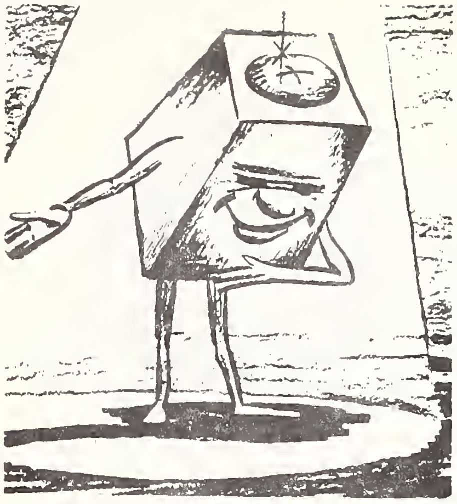
30.11 Checking Plans

The preliminary review of the plans for the project should be made in the field before any staking is started. A very careful check should be made to assure that drainage facilities are located properly and that drain pipes are of sufficient size to transmit the expected runoff. The location of all farm approaches and business entrances or residences should be checked. Notations can be made for any additional requirements necessary to serve new properties which have not been shown on the plans but which may have been in existance at the time right-of-way was secured. No additions, deletions, or revisions should be made to any entrances or condemned property or to controlled access of right-of-way without the approval of the Division Supervisor and the Construction Bureau.

30.12 Co-operation with Contractor

The Project Manager should consult the contractor as soon as possible after the project is awarded to co-ordinate the staking plans with the contractor's work schedule. These discussions may be held before the Preconstruction Conferences and if so, the plans should be reaffirmed at the Preconstruction Conference. The need to retain referenced control points and the possible cost to the contractor in terms of stake replacement and work delay awaiting new stakes may be completely discussed with the contractor.

If there is any doubt of full understanding of the staking method, stake markings, staking schedules, protection of control points or the State's intention to keep re-staking to a bare minimum, write a letter of explanation to the contractor. This written record may become a valuable aid in the event that portions of the work are not built to the established lines and grades.



U.S. DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY
WASHINGTON 25, D.C.

INTRODUCING MARVIN MARKER

My name is Marvin Marker. I belong to an extremely large family of bronze station markers which are property of the U. S. Coast and Geodetic Survey. Because of my 150-year's longevity, I was chosen to solicit your help in a serious family problem.

Our problem is the same as that faced by people throughout the world today -- SURVIVAL. Yet our concern, apart from man's, is not because of the present world situation. Our chances of survival are slim regardless of the world's condition! And they are getting slimmer all the time! That's why I am appealing to you.

Lately our lineage has suffered terrifically because of premature deaths. Last year, thousands of Markers met with ill-fated deaths. Hundreds were mistreated, abused, uprooted and thrown away. Some were even brutally murdered. Few, I am sorry to say, ever die comfortably of old age.

Although I am emotionally involved as a member of the family, I can't help but think that people, too, would become a bit emotional if they knew the terrific expense involved in replacing us. Someone told me that the Government spends thousands of dollars each year just replacing unfortunate Markers. (Boy! That sounds like an awful lot of the people's money, since they're always complaining about not having enough!!) And yet I'm sure that if people were made aware of a few things about us, 95% of these losses could be prevented.

From time to time we suffer through maliciousness. Halloween, without fail, finds pranksters attempting in various ways to pry us up. Souvenir hunters, too, frequently steal us for use as paperweights, bookends, or just for the thrill of an unusual memento. The laugh will be on them if they are ever caught, though! Imprisonment or a $250 fine hardly seems worth the thrill they receive from such frolicking.

Our biggest enemy, however, is the man behind the bulldozer or grader. Brother! On more than one occasion in my lifetime I have had to do some fast praying for fear that I would follow some of my relatives to the grave — an unfortunate victim of a crushed disk! I thank my lucky stars that the present owner of the property on which I live knows all about me, and my value to surveyors and engineers. He takes special precautions to see that I stay healthy, and that no man or machine damages me.

It's because of these well informed, thoughtful people who are careful to watch for us and for our distress signs, that many Markers live long, useful lives. Actually, we are supposed to be immortal. But, some of the family have died of old age, erosion or sedimentation because the services of a professional engineer were not engaged soon enough to save them.

Please, won't you perform a valuable service to your country and community by helping Markers live a normal life span? Engineers, businessmen, housewives, students, — Just about every citizen can help!

Remember these facts!

(1) Never remove a survey marker. Once this is done, the value of it is lost entirely, and replacement is costly.

(2) If there is construction going on in your area and you notice a survey mark which appears to be in the way, call it to the attention of the surveyor in charge to insure that he is aware of it.

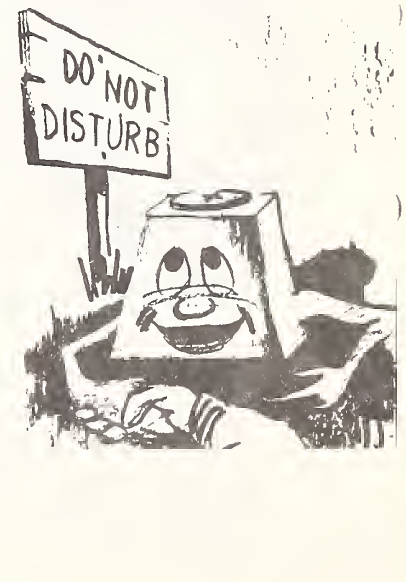
(3) If you see a survey mark which appears to be susceptible to damage of any kind, or which seems to be undergoing erosion or other "old-age ailments," flag it by driving stakes nearby and marking them with red ribbon, cloth, or plastic.

(4) In all cases, submit a report of your findings to The Director, Coast and Geodetic Survey, U.S. Department of Commerce, Washington 25, D.C.

When you respond to this appeal, you will be performing a tremendous service for your Government. And as for me and the Marker Family, you will be helping to achieve longer and better lives for Markers all over the World.

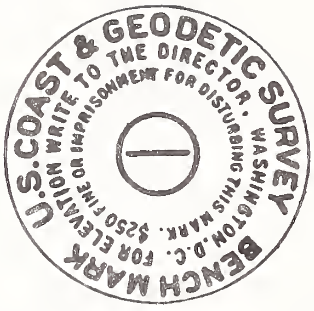
Thanks from the entire family!

HELP PRESERVE SURVEY MARKERS

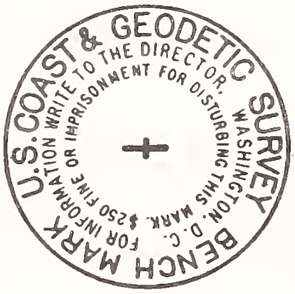


US COMM-CGS-DC PIO 2-62

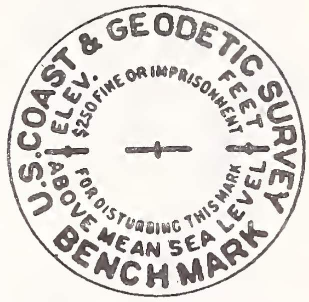
KNOW THESE MARKERS


U.S. COAST & GEODETIC SURVEY
FOR ELEVATION WRITE TO THE DIRECTOR, WASHINGTON, D.C.
$250 FINE OR IMPRISONMENT FOR DISTURBING THIS MARK.
BENCH MARK

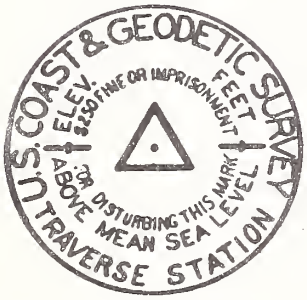
BENCH
(Old Type)


U.S. COAST & GEODETIC SURVEY
FOR INFORMATION WRITE TO THE DIRECTOR, WASHINGTON, D.C.
$250 FINE OR IMPRISONMENT FOR DISTURBING THIS MARK.
BENCH MARK

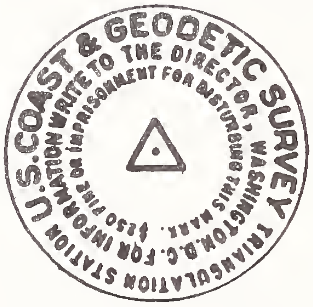
BENCH
(New Type)
Two Bench Marks Consolidated


U.S. COAST & GEODETIC SURVEY
ELEV.
FEET
ABOVE MEAN SEA LEVEL
$250 FINE OR IMPRISONMENT FOR DISTURBING THIS MARK
BENCH MARK

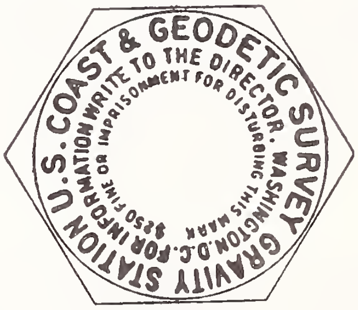
BENCH
(Old Type)


U.S. COAST & GEODETIC SURVEY
ELEV.
FEET
ABOVE MEAN SEA LEVEL
$250 FINE OR IMPRISONMENT FOR DISTURBING THIS MARK
TRAVERSE STATION

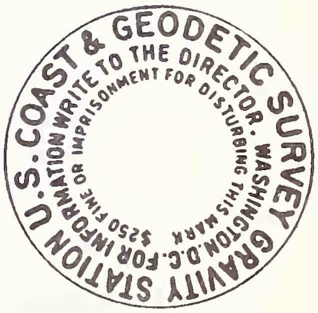
TRAVERSE


U.S. COAST & GEODETIC SURVEY
FOR INFORMATION WRITE TO THE DIRECTOR, WASHINGTON, D.C.
$250 FINE OR IMPRISONMENT FOR DISTURBING THIS MARK.
TRIANGULATION STATION

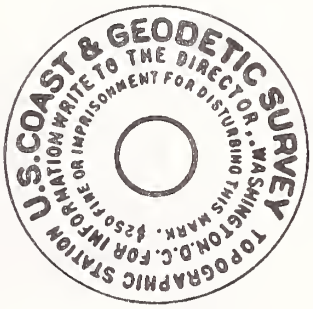
TRIANGULATION


U.S. COAST & GEODETIC SURVEY
FOR INFORMATION WRITE TO THE DIRECTOR, WASHINGTON, D.C.
$250 FINE OR IMPRISONMENT FOR DISTURBING THIS MARK.
GRAVITY STATION

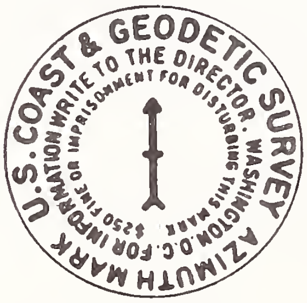
GRAVITY
(Old Type)


U.S. COAST & GEODETIC SURVEY
FOR INFORMATION WRITE TO THE DIRECTOR, WASHINGTON, D.C.
$250 FINE OR IMPRISONMENT FOR DISTURBING THIS MARK.
GRAVITY STATION

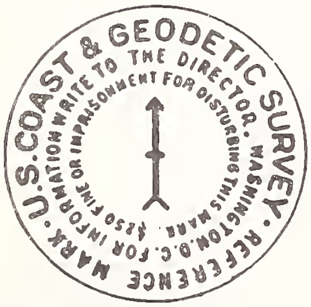
GRAVITY
(New Type)


U.S. COAST & GEODETIC SURVEY
FOR INFORMATION WRITE TO THE DIRECTOR, WASHINGTON, D.C.
$250 FINE OR IMPRISONMENT FOR DISTURBING THIS MARK.
TOPOGRAPHIC STATION

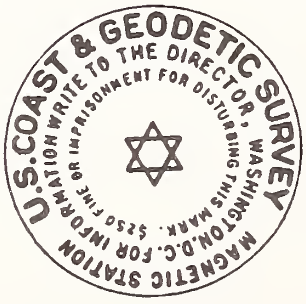
TOPOGRAPHIC


U.S. COAST & GEODETIC SURVEY
FOR INFORMATION WRITE TO THE DIRECTOR, WASHINGTON, D.C.
$250 FINE OR IMPRISONMENT FOR DISTURBING THIS MARK.
AZIMUTH MARK

AZIMUTH


U.S. COAST & GEODETIC SURVEY
FOR INFORMATION WRITE TO THE DIRECTOR, WASHINGTON, D.C.
$250 FINE OR IMPRISONMENT FOR DISTURBING THIS MARK.
REFERENCE MARK

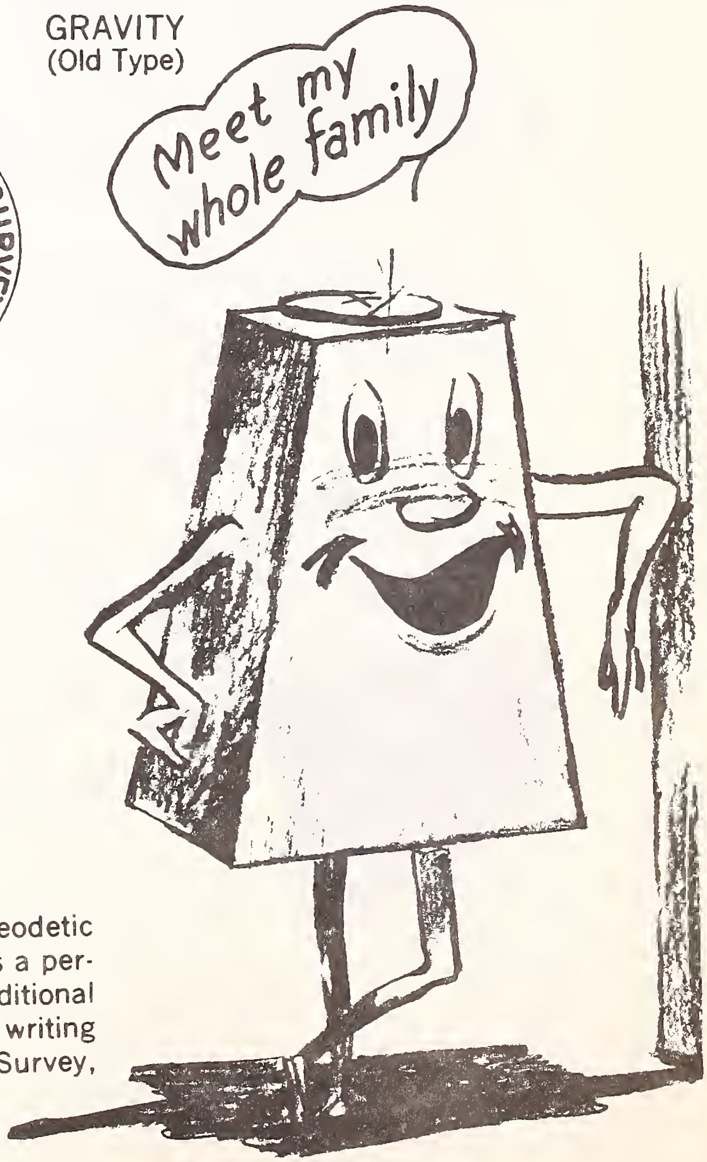
REFERENCE


U.S. COAST & GEODETIC SURVEY
FOR INFORMATION WRITE TO THE DIRECTOR, WASHINGTON, D.C.
$250 FINE OR IMPRISONMENT FOR DISTURBING THIS MARK.
MAGNETIC STATION

MAGNETIC

FACE LEGENDS

Standard bronze station marks of the Coast and Geodetic Survey that are set in concrete or bedrock to serve as a permanent mark for the particular station it represents. Additional information concerning these marks may be obtained by writing to the Director, United States Coast and Geodetic Survey, Washington 25, D.C.



RELOCATION OF BENCH MARKS

Frequently new construction or repairs to existing structures necessitates the destruction of bench marks, in spite of the fact that every effort has been made to place them where they will be as permanent as possible. This bureau has no funds from which to pay field parties to relocate these marks when they must be moved. If these marks are to be preserved for the use of all engineers and surveyors who may have occasion to use them, we must depend on the cooperation of engineers and others throughout the country for assistance in their preservation. Obviously it is to the best interests of all concerned that bench marks be relocated rather than destroyed.

There has been developed a routine method of handling such cases. If engineers who encounter our marks in the course of construction repair or maintenance operations will cooperate as outlined below, the destruction of useful bench marks will be very much reduced.

As soon as it becomes known that a mark must be moved, a letter should be sent to the Director, United States Coast and Geodetic Survey, Washington 25, D.C., attention Section of Leveling, stating the necessity for moving the mark and giving its designation. The designation consists of the letters and numbers stamped with dies on the disk. It is desirable to furnish a rubbing of the disk as well. (See p. 15) Upon receipt of this information, this office will send out a new disk properly stamped to show it has been reset.

The proper procedure, in most cases, is to establish the new mark in a safe place nearby and transfer the elevation from the old mark to the new one by means of an engineer's level and rod. The levels should be run in deplicate to avoid the possibility of large errors, and all readings should be made to three decimal places in order to preserve the accuracy of the original elevation.

The old mark should not be disturbed until the observation involved in the transfer of elevation have been checked by the observer or the recorder. An assumed elevation for the old mark may be used in the transfer, since we are principally concerned with the difference in elevation between the old mark and the new one established to replace it.

After the new mark has been established and the elevation transferred to it, the old disk should be broken out and returned in a franked mailing sack which will be supplied for the purpose. A complete report on the action taken, including a description of the location in which the new mark is established and a copy of the field notes involved in the transfer of elevation, should also be forwarded to this office in a franked envelope which will be furnished.

The cooperation which individuals and organizations may extend to this bureau in preserving bench marks will be a service, not only to this bureau and other government surveying organizations, but to all who may have occasion to use this marks in the furture.

The above information was taken from the Bulletin
"Control Leveling", from the U.S. Coast & Geodetic Survey
July 22, 1946.

III-31 CONSTRUCTION SURVEYS FOR ROADWAYS

31.00 References

Standard Specifications: Section 5

Field & Office Standards: Sheets 40, 41, 42 and 43

31.01 Re-establishing Centerline

The centerline, or another line as designated on the plans as the base line, from which measurements are to be taken for laying out the work and setting stakes for horizontal and vertical control is one of the first procedures in staking a highway project. It is obvious that any stakes set on the centerline will be destroyed during the construction operations. Centerline need only be temporarily marked for use during staking. During the course of construction the centerline or base line will have to be re-established frequently depending on the nature of the construction under way. Therefore, a sufficient number of control points on the line must be tied in or referenced to fixed objects such as iron pins, hubs and tacks, etc. so the line may be readily re-established at any time during construction or after completion of the project.

The plans should be checked and notebooks prepared before any staking is begun and at least one set of plans is to be available for use of the staking party at all times. Occasionally errors in the plans or the original field location are found by the staking party. Notations of these errors are to be made on the field plans as well as in the notebooks. All of the curve data shown on the plans should be checked and transferred into the transit notes before staking is begun.

A transit book is to be prepared in advance of staking from information on the plans. Plenty of space should be left between entries to allow for additional information that is unanticipated and to prevent crowded notes. Transit notes are unique in their construction since the stations are listed up the page consecutively from the beginning station onward to the ending station because this is the way the surveyor views the centerline and it is more convenient to describe details as he sees them. Similarly, the sketches on the right hand page of the transit notes will begin at the bottom of the page and progress upwards to the top of the page. The stationing of all transit points shown on the plans should be entered in the transit notes at the proper place according to the station numbers. Reference points or ties should be entered opposite the corresponding station number on the right hand page. The appropriate station number of piers, bents, and end bents of each structure shown on the plans should be entered into the field book so the centerline location for these structure points may be established as the centerline is run.

The right-of-way lines on each side of centerline and their distance from centerline should be shown on the right hand page of the transit notes.

A. Staking Centerline

Accepted survey practice is to be used when staking centerline or performing other survey functions. Care should be taken to assure that the chain is in a horizontal plain. Too frequently the alignment of the tape is set very precisely, whereas the vertical control is established by eye only instead of using a hand level. After locating the beginning of the project from the nearest established transit point, each station should be set from there on. Half stations or other plusses necessary for right-of-way breaks, curves, topography, or for the centerline of each structure should also be set at this time. The staking party should be organized for the maximum efficiency by locating transit points shown on the plans ahead of centerline staking or arranging to set these points concurrently with centerline staking where efficiency can be gained.

Errors in chaining may occur or be discovered as the centerline is being run and staked. Small chaining errors should be corrected at the first POT or at the first PT after the error is found. Errors resulting in an equation greater than one foot should be recorded. When very large errors in chaining occur, an equation should be made, as near the point of the error as possible.

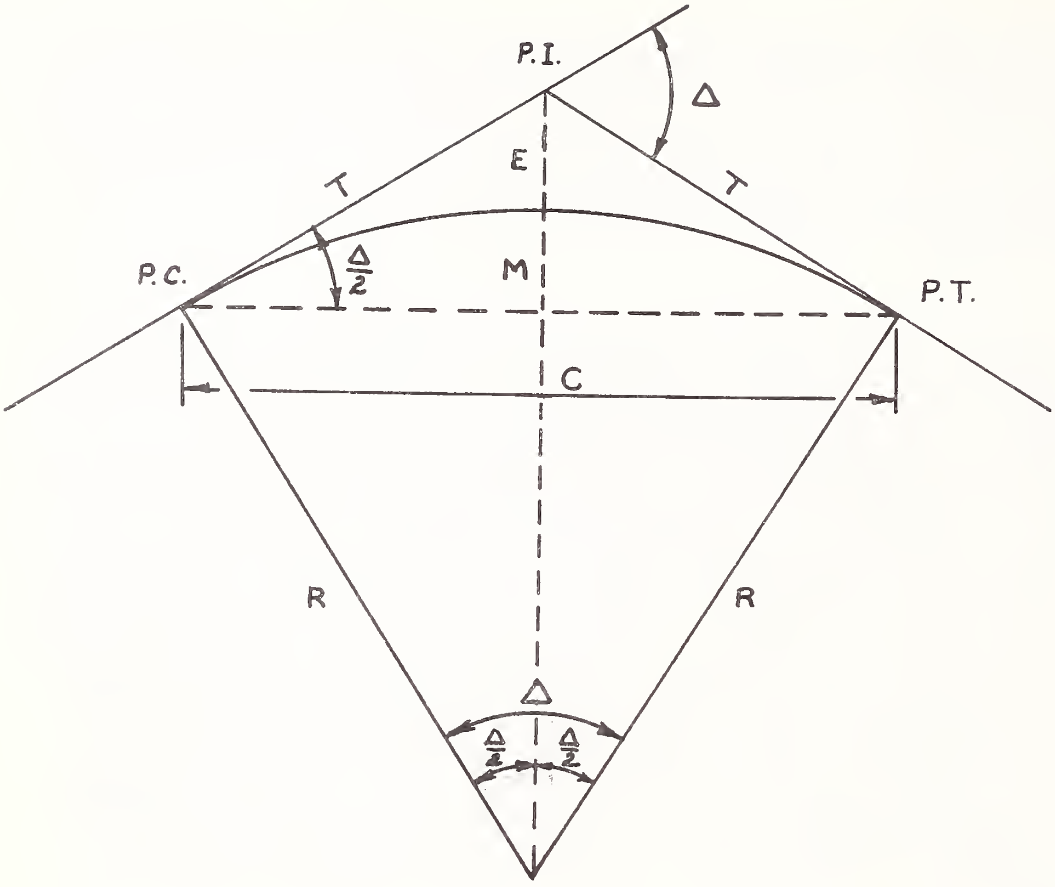
An equation is a survey point that is used to adjust errors in the measured distances and has two station numbers. One of the station numbers is used as a reference stationing for all measurements from the point back towards the beginning of the project. The other station number is used as a reference station from which all measurements from that point ahead are taken. An example of an equation is Station 201+50.0(back) equals 201+28.3(ahead). This equation is called a plus equation because the length of the line has been increased and in this instance the increase is 21.7 feet.

The engineer in charge of the survey team reestablishing centerline should use planning and foresight in locating and referencing points. Transit points should be set so they may be re-established from other transit points along the survey line, thus, if transit points are lost they may be re-established by extending tangents from other established points or by forming an intersection of known tangents.

B. Simple Curve

Specific information on the computation of curve data can be found in a number of engineering handbooks, to which the engineer-surveyor is referred, for thorough coverage. Highway curve data is computed from the arc definition which states that a one degree curve is the curve of a radius such that one degree of central angle subtends an arc of 100 feet in length. The value of various curve functions vary inversely with the degree of curve for any given central angle, for instance, the radius varies inversely with the degree of curve such that the radius of a one degree curve is set at 5730 feet; therefore, the radius of a two degree curve is one-half of 5730 feet, the radius of a three degree curve is one-third of 5730, and so on. The following tabulation, Figure III-1, lists the basic circular curve formulas for use in computing simple curve functions.

Curves are usually staked for each station and each half-station, except for the odd distance from the PC or PT to the first station on a curve. The length of curve is computed along the arc, but the chain is stretched along a chord between points on the curve, therefore, a correction may be necessary depending on the sharpness or degree of curvature. However, chord corrections may be disregarded for 100 foot chords used for curves up to 6 degrees; 50 foot chords for curves up to 12 degrees; 25 foot chords for curves up to 24 degrees, and 10 foot chords for curves over 24 degrees.



D = Degree of Curvature in Degrees

L_c = Length of Curve

R = Radius of Curve

T = Tangent Distance from P.C. to P.I. and P.I. to P.T.

$D = \frac{5729.5780}{R}$ $T = R \tan \frac{\Delta}{2}$ $L_c = \frac{100\,\Delta}{D}$

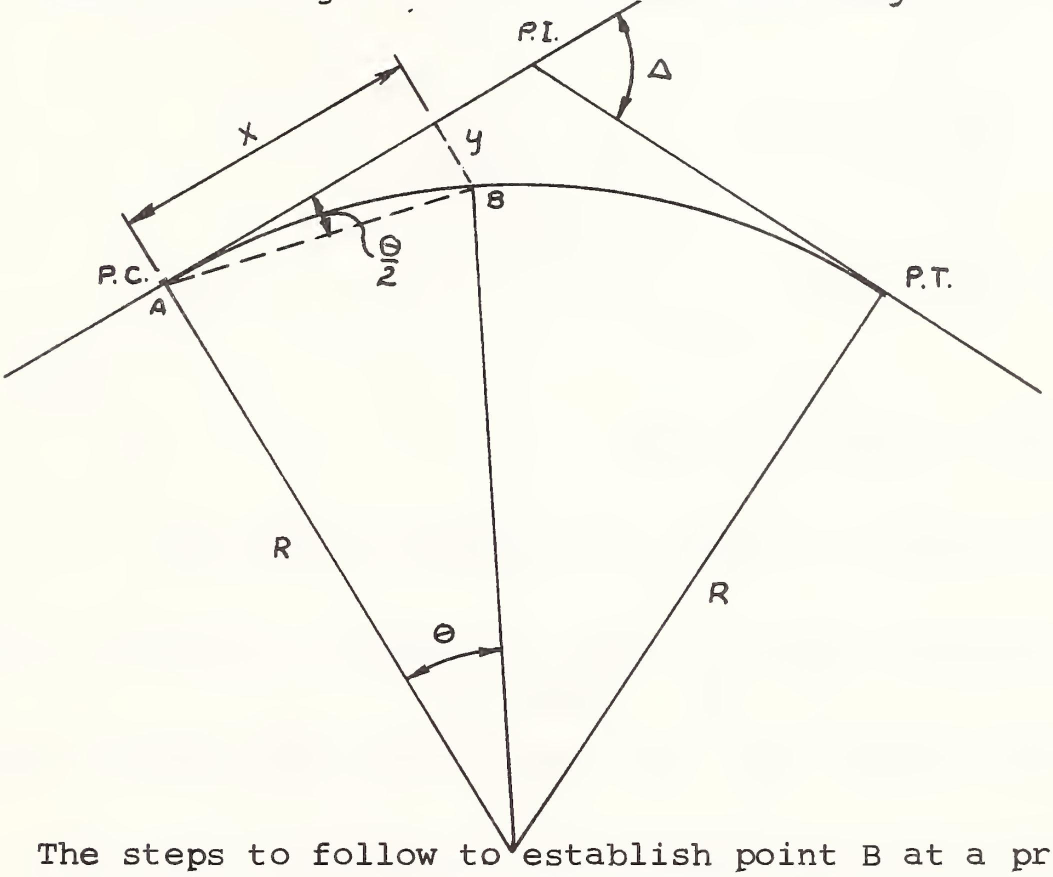
$M = R(1-\mathrm{COS}\tfrac{1}{2}\Delta)$ $E = T \tan \frac{\Delta}{4}$ $C = 2\ R\ \mathrm{Sin}\ \frac{\Delta}{2}$ or

$C = 2\ T\ \mathrm{COS}\ \frac{\Delta}{2}$ or Chord Length (for any arc Length = S)

$$= 2\ R\ \mathrm{Sin}\left[\frac{(S)\ (D)}{(2)\ \ (100)}\right]$$

Fig. III-1

On many surveys the entire curve cannot be seen from the PC or the PT. Whereby intermediate setups or alternate methods of setting each centerline stake along the curve may be necessary. Figure III-2 is an example of the tangent offset method for establishing centerline stations along a curve from the semi-tangents.



The steps to follow to establish point B at a pre-determined station on the curve are as follows:

1. Subtract station at P.C. from station at B to determine arc length AB.
2. Determine deflection angle θ/2 from curve data for the point in question, s=Arc length AB

   $\frac{\theta}{2} = \frac{(S)\ (D)}{100\ (2)}$ or $\frac{\theta}{2} = \frac{S}{L_c} \times \frac{\Delta}{2}$

3. Determine chord length AB from: chord length (AB) = $2 R \sin (\frac{\theta}{2})$.
4. $X = AB \cos \theta/2$

   $Y = AB \sin \theta/2$

Fig. III-2

EXAMPLE:

P.C. Station 15+24.60

$D = 3^{\circ}\ 42'$

$R = 1548.5346$ ft.

$\Delta = 27^{\circ}\ 24'$

$L_c = 740.540$ ft.

To set a point at station 17+00

1. Arc length = (17+00) -(15+24.60) = 175.40 Ft.

2. Deflection angle $\frac{e}{2} = \frac{(175.4)\ (3.70)}{100\ (2)} = 3.2449^{\circ} = 3^{\circ}\ 14.7'$

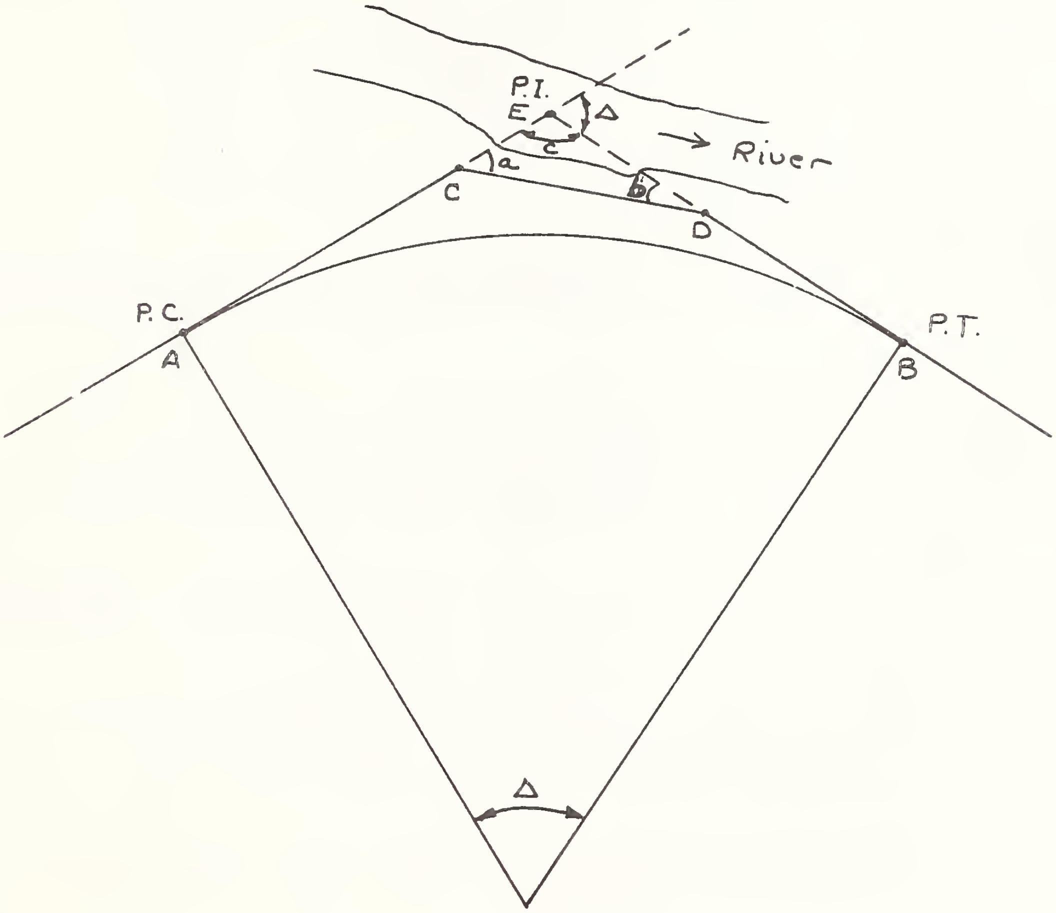
3. Chord Length AB = (2) (1548.5346) Sin(3.2449) = 175.3118

4. $X = (175.3118)\ (\text{Cos } 3^{\circ}\ 14.7') = 175.03'$

   $Y = (175.3118)\ (\text{Sin } 3^{\circ}\ 14.7') = 9.92'$

Fig. III-2a

In some cases the Point of Intersection(P.I.) of the tangents is inaccessible and therefore, cannot be used as a control point. In order to determine Δ and other data necessary for locating a curve the following procedure is suggested.



1. Locate points C and D on their respective tangents at any convenient position.

2. Measure angle a, distance CD and angle b.

3. Then $\Delta = a + b$ & $c = 180 - \Delta$

4. Solve for CE and ED by law of sines.

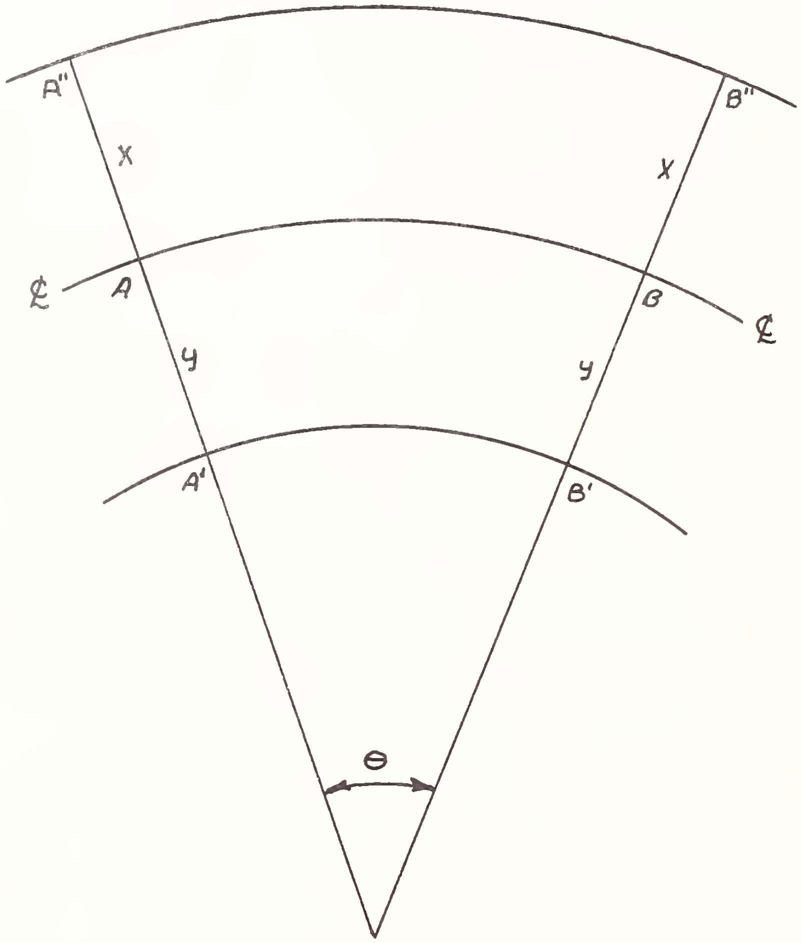
$$ED = \frac{\sin a}{\sin c}(CD) \quad \& \quad CE = \frac{\text{Sin } b}{\text{Sin } c}(CD)$$

5. Once the tangent lengths (T) of the curve are established from the curve data, the P.C. can be set by measuring back from point C a distance equal to T - CE.

6. The P.T. can be set by measuring ahead from point D a distance equal to T - ED.

Fig. III-3

It is often necessary to locate outer or inner concentric curves for various reasons and in order to maintain accurate stationing as compared to the centerline, the outer or inner arcs must be adjusted to correspond to the distances laid out on centerline. See Fig. III-4



X = distance from centerline to outer arc measured perpendicular to the centerline.

Y = distance from centerline to inner arc measured perpendicular to centerline.

R = Radius of curve

D = Degree of curvature

Δ = Total central angle (degrees)

L_c = Length of curve on centerline

$A'' B'' = AB + \left[(X)(.017453)(\theta)\right]$

$A' B' = AB - \left[(Y)(.017453)(\theta)\right]$

θ = Central angle for Arc AB

Note that A'B' is less than AB and A"B" is greater than AB.

Example: Given: X = 50 ft. Y = 40 ft. $\Delta = 30^\circ 30'$
$D = 6^\circ 00'$ AB = 50 ft.
Find: A'B' & A" B"

Fig. III-4

1. $L_c = 100 \frac{\Delta}{D} = \frac{30.5^\circ}{6} (100) = 508.33$ ft.

2. Central angle for 50 ft. arc on centerline $= \frac{D}{2} = 3^\circ = \theta$

   or Central angle for any length arc (s) on centerline =
   $\frac{S}{L_c} \times (\Delta) = \frac{50}{508.33} \times (30.5^\circ) = 3^\circ = \theta$

3. $A''B'' = 50 + (50)(.017453)(3) = 52.62$ ft.

   $A'B'' = 50 - (40)(.017453)(3) = 47.91$ ft.

Alternate Solution for Concentric Curves

R = Radius on ℄

R'= Radius of inner concentric = R - Y

R"= Radius of outer concentric = R + X

Example: Given X = 50' Y = 40' R = 954.93 AB = 50'

1. R' = 954.93 - 40 = 914.93

   R" = 954.93 + 50 = 1004.93

2. $A'B' = \frac{R'}{R} \times AB = \frac{914.93}{954.93} \times 50 = 47.91'$

   $A''B'' = \frac{R''}{R} \times AB = \frac{1004.93}{954.93} \times 50 = 52.62'$

For more complete information on circular curves refer to the book "Route Location and Design" by Thomas F. Hickerson.

Fig. III-4a

C. Spiral Transition Curves

Spiral transitions are provided at each end of the circular curve to provide a gradual transition from the tangent to the full super-elevated curve. A spiral transition has the property of an ever-increasing curvature starting with 0 degrees and ending with the same degree of curvature as that of the horizontal curve. Information on the spiral curve and super-elevation transitions will be found on the plans. For complete information on the computation of spiral curve transitions refer to the book "Transition Curves for Highways" by Joseph Barnett of the BPR, or "Route Location and Design" by Thomas F. Hickerson. See Figure III-5a, b, c, for spiral curve offset computations.

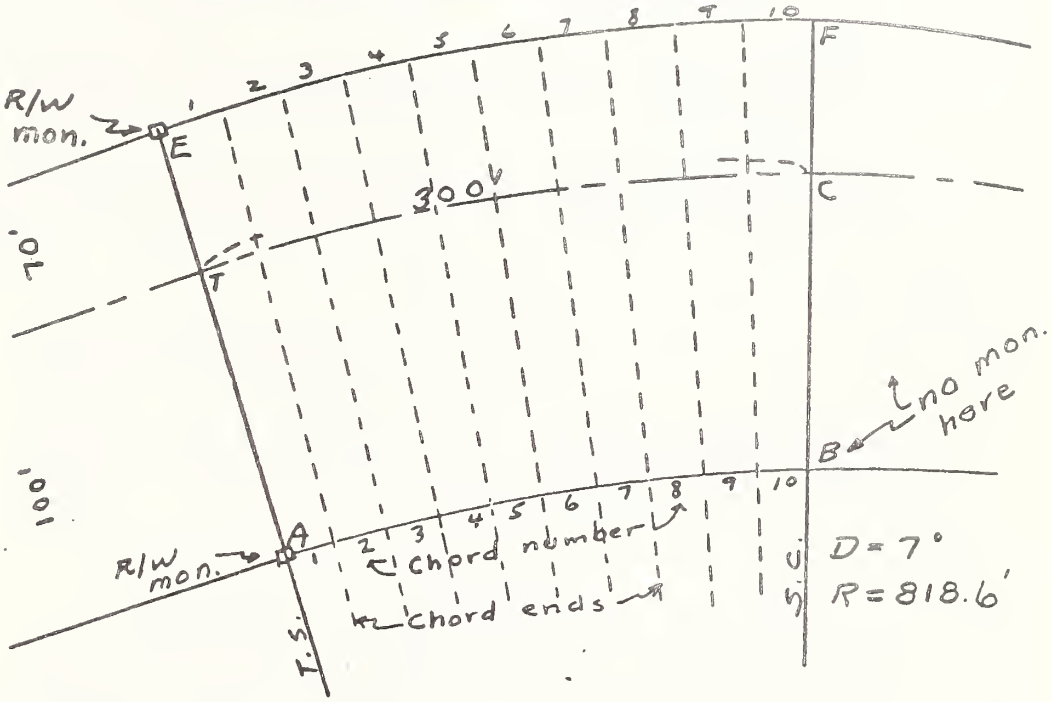
31.02 Bench Marks and Leveling

Bench marks should always be established outside of the construction limits. Bench marks that have been established on a location survey and are in the way of construction should be re-established outside the construction limits. Bench marks should be set no more than 1,000 feet apart using long iron pins, bars, pipes, concrete monuments, bridge abuttments, or some similar control for permanency. The height of fill and depth of cut should be taken into consideration when establishing bench marks so that locations are convenient for future surveys performed before, during, and after construction of the roadbed. Strategic locations for bench marks are generally as follows, but the engineer should take into consideration the terrain of the country and the type of work underway.

1. Each end of large structures.
2. Points of change from cuts to fills.
3. Mid-height of a side hill cross section.
4. 25 foot differences in elevation on rolling terrain.
5. Not to exceed 1,000 foot intervals in level country.

Bench marks established either by the location survey or by the construction survey team should be tied in with the United States Geological Survey Department or the U.S. Coast and Geodetic Survey when possible. If these survey data monuments have not been placed near enough to the construction projects, the State's own level circuit should be run and contain an accuracy of 1 in 5000. This level circuit should be checked and the maximum error should be no greater than 0.05 times the square root of one mile, for the desired one in five thousand accuracy.

PARALLEL SPIRAL CURVES



The TOTAL CHAINING CORRECTION for an offset spiral is equal to 1/2 the total chaining correction for an offset line the same distance from a simple curve with the same degree of curvature and length as the spiral.

Formula for determining AB & EF

R = radius, in feet, of circular curve
L = length of spiral on C L
P = distance CL to parallel spiral (R/W above)
C = correction applied to CL spiral to obtain length of parallel spiral

$$C = 0.5\left(\frac{P}{R} \times L\right)$$

T = correction in CL length for end of any chord from TS (or ST.).
M = correction for each chord length
N = chord number as decimal of total (Ch. 2 = 0.2)

$$T = N^2 \times C. \quad M = T_2 - T_1 \ ; \ T_5 - T_4 \ ; \ T_9 - T_8 \ ; \text{etc.}$$

Any chord number divided by two, and squared, times the total correction will give the chaining correction from the T.S. (or the S.T.) through the chord used.

CSN-05A

Fig. III-5a

COMPUTATION EXAMPLES

See CSN-05A

$C = 0.5 \left(\frac{P}{R} \times L\right)$ P = 70'; R = 818.6'; L = 300'

$C = 0.5 \left(\frac{70.0}{818.6} \times 300\right) = 0.5 \times 0.0855 \times 300 = 12.83'$

Thus: TC = 300'; EF = 312.83'

P = 100'; R = 818.6'; L = 300'

$C = 0.5 \left(\frac{100.0}{818.6} \times 300\right) = 0.5 \times 0.12216 \times 300 = 18.32'$

Thus: TC = 300'; AB = 281.68'

Determination of chord lengths: "Table X"

Using 70' R/W $T = N^2 \times C$

Chord					T
1	$.1^2$	x	12.83	=	0.128'
2	$.2^2$	x	12.83	=	0.513'
3	$.3^2$	x	12.83	=	1.155'
4	$.4^2$	x	12.83	=	2.053'
5	$.5^2$	x	12.83	=	3.208'
6	$.6^2$	x	12.83	=	4.619'
7	$.7^2$	x	12.83	=	6.287'
8	$.8^2$	x	12.83	=	8.211'
9	$.9^2$	x	12.83	=	10.392'
10	1.0^2	x	12.83	=	12.830'

T = total correction from T.S. to end of any chord.

e.g. - Total correction from E to end Chord 5 = 3.2'; from E to end Chord 9 = 10.4' plus (9x30) 270 = 280.4'

To obtain correction for each chord: subtract. "Table Y"

$M_1 = 0.13$
$M_2 = 0.51 - 0.13 = 0.38$
$M_3 = 1.16 - 0.51 = 0.65$
$M_4 = 2.05 - 1.15 = 0.90$
$M_5 = 3.21 - 2.05 = 1.16$

$M_6 = 4.62 - 3.21 = 1.41$
$M_7 = 6.29 - 4.62 = 1.67$
$M_8 = 8.21 - 6.29 = 1.92$
$M_9 = 10.39 - 8.21 = 2.18$
$M_{10} = 12.83 - 10.39 = 2.44$

(See following page)

CSN-05B

Fig. III-5b

Computation Examples (Continued)

Chord lengths on 70' R/W line: (Corrections Table Y)
Chord 1 on CL is 30'; all others are the same

Chord 1 : 30.00 + 0.13 = 30.13   5 = 31.16   8 = 31.92
Chord 2 : 30.00 + 0.38 = 30.38   6 = 31.41   9 = 32.18
Chord 3 : 30.00 + 0.65 = 30.65   7 = 31.67   10 = 32.44
Chord 4 : 30.00 + 0.90 = 30.90

Total distance from E to end of chords:

1 - 30.00 + 0.13 = 30.13   5 - 153.21   8 - 248.21
2 - 60.00 + 0.51 = 60.51   6 - 184.62   9 - 280.39
3 - 90.00 + 1.16 = 91.16   7 - 216.29   10 - 312.83
4 - 120.00 + 2.05 = 122.05

(CL chords plus corrections in Table X)

To obtain chaining corrections for the 100 ft R/W Line, prepare data like in Table X, using C = 18.32. Then proceed in same manner as for 70' line, except corrections are to be subtracted.

Curve deflections at end of each chord on the parallel line are the same as for end of each chord on centerline.

To run a line perpendicular to the centerline spiral at any point, take twice the deflection (Z^o) for that point, sight on T.S. (or S.T.), turn

$90^o + Z^o$ for the outside of the spiral
$90^o - Z^o$ for the inside of the spiral.

The above procedure seems long and complicated. However, it is purposely that way for the beginner. Practice will develop short cuts.

See Table VI, Page 188, "TRANSITION CURVES FOR HIGHWAYS", by Joseph Barnett; "ROUTE SURVEYS & DESIGN" by Thomas F. Hickerson, A.S.C.E. (McGraw-Hill)

CSN-05C

Fig. III-5c

When errors occur in bench mark elevations, these should be corrected in a manner that will not affect the elevations of succeeding bench marks. If a minor error were to change the elevation of succeeding bench marks an equation in the elvations should be set up at a point where the error is noted. A minor adjustment in grade may be necessary in this event. Major errors in bench mark elevations should be referred immediately to the Division Construction Supervisor who will work out the details for correction. It is not advisable to accumulate small variations found in elevations of the original bench marks. To minimize the accumulation of small errors, the back-site and fore-site distances should be kept approximately equal. Bench marks should be used for turning points wherever possible. The level rods should be waved slightly to obtain the lowest reading. Plant the level firmly, level it and be sure it remains level when carefully reading the rod.

Each bench mark is to be described in the level book giving elevation, station and distance to the survey line, together with an accurate description of the object on which the bench mark is established. Level notes can be easily arranged in a uniform, neat, manner yet mistakes can sneak in. To insure accurate results and to avoid errors the notekeeper must continually check turning points, bench marks, rod readings, and computations.

31.03 Staking Right-of-Way

The right-of-way plans and a transcript of each right-of-way parcel must be used to insure that right-of-way, as shown on the plans, is staked as legally described and intended. Should assistance be necessary, the Division Right-of-Way Agent may be contacted to help interpret the information. Stake the right-of-way line on both sides of the construction centerline. The distance between stakes will vary according to terrain but intervals of 100 feet are preferred on level ground and 50 feet on curves. Stakes should be set at all corners and at changes in width or direction. Property owners use these stakes to reset fences, determine property lines, etc. Therefore, accuracy is important. Mark the front side of the stake with "R/W", and the distance from centerline. Print the stationing on the back of the stake.

31.04 Clearing and Grubbing Stakes

The Standard Specifications propose three methods of measuring, clearing and grubbing units. A lump sum basis, area basis and linear basis. Therefore, staking must be compatible with the method of measurement. Clearing and grubbing limits are always established within the right-of-way with due allowance made for movement of contractors equipment. Sharp breaks in the width of the clearing line may be avoided by adjusting the clearing stakes. Clearing lines on the inside of curves and at intersections should be given special attention to provide adequate sight distance when the right-of-way width will permit this.

Distances will be measured to the nearest foot and stakes or laths placed to clearly distinguish the intended limits. Stakes or lath should be spaced approximately 100 feet apart, as a general rule, and placed so one lath can be seen from the next one, etc., but the spacing will be dependent upon terrain and denseness of the foliage. When clearing areas of heavy timber, clearing stakes should be set in a somewhat irregular alignment thus when clearing is completed a more natural appearance will result. Stakes or lath properly set are marked "clear" and usually flagged.

The stakout notes will show stationing, distance left and right, date and names of persons making the stakeout. The areas that have been staked should be reviewed by the contractor so that he is aware of the staking procedure, the general areas to be cleared or grubbed and can raise any questions before work begins.

A limited number of trees and shrubs may be retained to blend into the right-of-way and adjacent terrain, providing screens for unsightly areas, and enhancing the natural appearance. Mark the trees to be saved with a red cloth or other suitable identification and inform the contractor that trees so marked are not to be cut. Trees and shrubs to be retained should be only sound, vigorous, of a desirable species, and not create future maintenance problems.

31.05 Slope Staking

Slope staking and measurement of earthwork quantities is an area where more disputes with contractors arise than any other phase of highway work. Naturally, cross sectioning and setting slope stakes by competent, experienced personnel, properly equipped and instructed is a most desirable goal. However, the seasonal workload requires hiring inexperienced personnel and other factors occasionally prohibit all survey personnel from being the ultimate in competency and experience. Therefore, it behooves the Project Manager to do careful planning and sufficient preliminary work in ample time to permit cross-sectioning work to follow in an orderly manner. Construction cross-sections should be taken wide enough to include all possible areas that might be disturbed. This will help eliminate back tracking and extending cross sections when later construction activities demand wider areas.

All such preliminary work as centerline staking, establishing bench marks and offset lines and preparing a grade book or a system of grade computation sheets will greatly aid the cross sectioning and slope staking party. When clearing and grubbing work is necessary prior to cross sectioning and slope staking, it will be wise to anticipate the most probable location of slope stakes. Cross sectioning will usually be performed when slope staking but after clearing and grubbing is completed. Sections will be taken at all breaks in the centerline profile and at all other breaks in topography within the roadway prism and at cut to fill transitions.

The normal cross-section interval will be 50 feet, however, in flat, low terrain 100 foot intervals may be used; whereas, in rugged or mountainous terrain 25 foot intervals may become necessary. Other cross-sections must, of course, be taken at odd stations where significant changes in elevation are noted. Extend the cross-sections beyond construction limits a minimum of ten feet, but in areas where overbreak or slides are anticipated the cross sections should be extended further.

Construction volume computations may change significantly from the plan quantities unless cross-sections are taken on a line truly perpendicular to the centerline on tangents and to radius lines on curves. Right angle prisms may be used to determine the perpendicular line on generally level terrain, but it may be necessary in rough or heavily timbered terrain to use a transit for right angles. The instrument height is to be recorded to the nearest 0.01 foot and rod readings taken to the nearest 0.1 of a foot from a rod held vertically. In very rugged terrain it may be necessary to run a series of off-set lines parallel to the construction centerline before slope staking and cross sectioning is done in order to maintain right angles and to provide another line of elevation points.

An allowance should also be made for earthwork volumes around curves by decreasing the spacing of cross-sections. This procedure will help compensate for inaccuracy of the average end area method (a specification requirement) of computing earthwork quantities around curves. When encountering horizontal curves the cross-section interval should be as follows: For curves less than a 5,000 foot horizontal radius, use 50 foot intervals; 300 foot radius or less, 25 foot intervals; and for 100 foot or less, 10 foot intervals. Sections should always be taken at the P.C., midpoint and P.T. Use 50 foot intervals on vertical curves when the mid-ordinate between the curve and the chord varies 0.2 foot or more between stations.

As the depth of cut increases and virgin terrain is encountered, it is becoming a common practice in highway back-slope design to build compound slopes or slopes with benches or breaks in the back-slope. The staking practices now in existence will give generally satisfactory results with only minor changes. It is suggested that only sufficient reference to cut depth be given to allow excavation down to the bench break then re-establish another reference stake at or near the first bench or break to allow excavation down to the next bench, etc. This method of staking insures that benches or breaks will be constructed correctly and has the advantage of simplicity. However, any other method that will provide proper slopes and place benches of the designed width in the correct location, will be satisfactory.

Cut and fill stakes should be marked with the stationing, depth of cut or fill, the slope and distance to the hinge point (shoulder or ditch bottom).

When cross-sectioning steep slopes, efficiency and speed can be aided by using reference hubs wherever possible. Elevations that are above the height of the rod, or above the height of the instrument can be marked on the reference hub to be "picked-up" on another set of cross-sections. A reference line may also be used. The zero end of the tape should be held on centerline in most cases and the cross-sections taken right and left of construction centerline and extending to the right-of-way line or beyond the construction limits or construction permit. A prismoidal correction is rarely used but may be required on the inside of circular ramps to correct earthwork computations because of the extremely short radius curves; the main line sections should then be extended or a supplemental base line used to cover these locations. Notes for staking the grade in ramps or interchange areas should be made up ahead of time and should be sufficiently accurate to allow ready staking, but not so precise that weeks will be taken to make these notes.

31.06 Staking Borrow Pits

Modern roadway construction is making more frequent use of borrow material to maintain a more uniform grade line and to construct interchange ramp areas in locations where roadway excavation material is not readily available. One of the primary considerations in removing material from a borrow site is determining how much material has been removed for roadway construction and where it was placed. Other considerations involving borrow sites are: topsoil removal and replacement, proper drainage and appearance after the borrow material has been removed. Clear definition of the borrow limits around the perimeter of the site are necessary in order to comply with the intent of the plan description and the wishes of the landowner as he has indicated on the agreement or permit. Borrow areas should be screened from the traveling public by the natural terrain or a row of trees. Borrow sites that are not screened should have their side slopes blended with the natural rolling groundline to provide a neat and pleasing appearance. For complete description of reclamation requirements refer to Section II-21.

The level datum for borrow sites is to be tied in with the road way bench marks where possible. Where borrow pits are located adjacent to the roadway, the roadway cross-sections may be extended for complete coverage of the borrow site. Where it is not practical to tie the borrow site elevations in with the roadway level datum. at least two bench marks should be established outside the construction operations and referenced to an assumed elevation. The borrow site notes should contain a sketch of the borrow location including fences, base line stationing, witnesses, references, bench marks, buildings, borrow limits, north arrow, a description of the section township, range and other pertinent information that would allow another person to re-establish or carry on the work.

Topsoil is to be removed to the required depth and replaced after the borrow material has been excavated and the pit neatly dressed. The topsoil quantities are to be kept separate from other excavated materials. This may require cross-sectioning and computation before the topsoil material is removed; after the topsoil material is removed; and after all the borrow material has been removed. Topsoil quantities thus arrived at will preclude the claims for increased quantities which can often be exaggerated by the contractor when no firm quantities or measurement thereof exists.

Two methods of staking a borrow site may be found in Figure III-6. Borrow pit cross-section notes are similar to other survey notes in that the date, weather information, and members of the crew are to be recorded for each day. These notes should be neat and well kept. Figures that are in error should be crossed out and the correct figure written above. Do not erase.

31.07 Finish Grade Stakes

Line and grade control stakes will be set when the rough grading is sufficiently complete to allow finishing operations. Job conditions and the contractors intended operation are factors that will determine the most economical method of establishing the required line and grade. It is generally helpful, at the contractor's request, to place lath with cut and fill markings at reasonable intervals to allow the contractor a more firm indication of the need for finishing prior to setting of blue tops. However, it is the contractors responsibility to complete rough grading of the roadway to within a half a foot or so of the true grade before he requests blue tops. It will help contractor-engineer relations to set rough stakes or laths, but this practice should not take precedence over other pressing work such as setting final blue tops where they are required in other locations. It is well to discuss with the contractor how and when rough-grading stakes will be established so that both the engineers schedule and the contractors operation will compliment each other and thereby minimize delays.

Finish grade stakes "blue tops" are to be set at 50 foot intervals along the shoulder line, quarterline and centerline on tangent sections or as needed to provide the proper construction of the roadway section. It may be necessary to set blue tops at 25 foot intervals around curves depending upon the radius and where transitions or changes in super elevations occur. The top of the stake is to be driven to the proper elevation and marked with crayon or paint to indicate that its top is at grade.

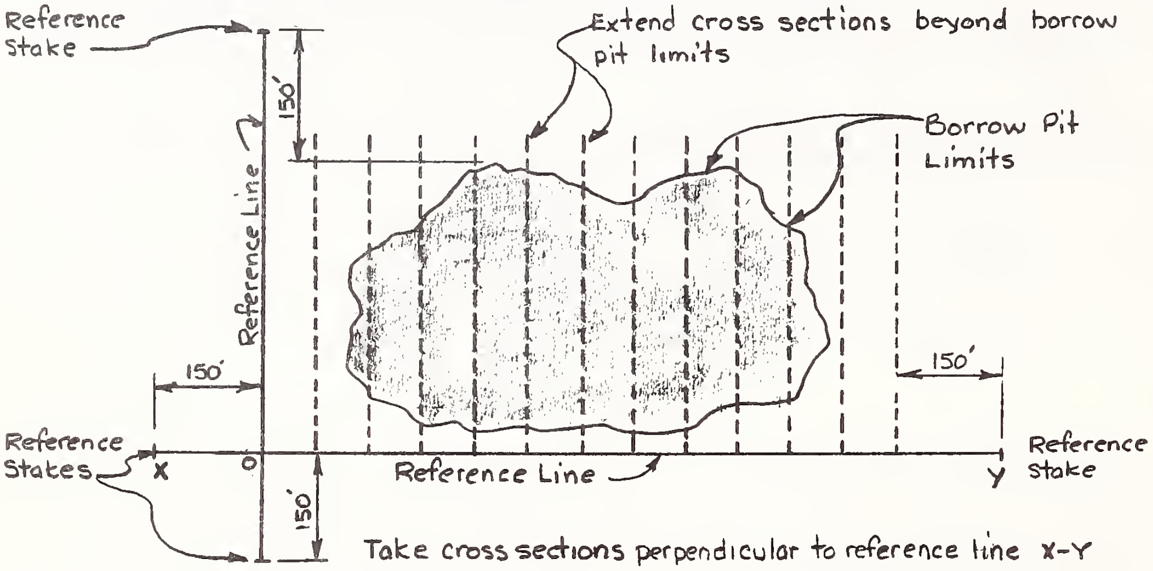
Care should be exercised to provide a smooth transition where the roadway grade meets an existing bridge or other changes in elevation occur. Changes in elevation should be drawn out over a long distance to make the transition as gentle as possible.

Grade and line for concrete paving are usually established along the shoulder line by a series of stakes set at 25 foot intervals, to approximately 0.01 foot accuracy and offset a uniform distance away from construction machinery. The contractor may then place iron stakes to support a piano wire at a uniform height above the true grade and to the same degree of accuracy as the original grade control was established. When the piano wire has been properly set and checked, small deviations may be observed by sighting along the wire. Corrections must be made, when needed, before accepting the position of the wire as accurate.

BORROW SITE CROSS SECTIONING

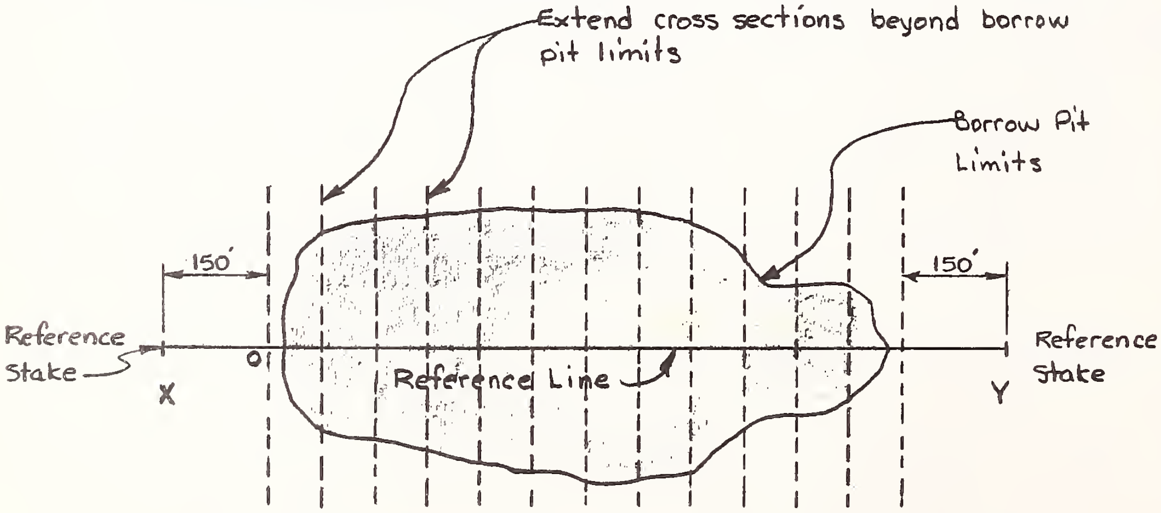
Take cross sections at each intersection of lines forming a 25' grid network. Use other points, as necessary, to show the true ground surface. Distances or dimensions shown below are for the surveyors guidance. Use judgement to fit the survey to the natural terrain.

1. Typical Borrow Excavation Site



Take cross sections perpendicular to reference line X-Y

2. Borrow From Old Embankments or Long Rows of Material



Take cross section perpendicular to reference line X-Y

Figure III-6

III-32 CONSTRUCTION SURVEYS FOR SMALL DRAINAGE FACILITIES

32.00 References

Standard Specifications: Sections 52 through 77

32.01 General

The proposed flow line elevation for outlet ditches, sewers, channel changes, culverts and other drainage facilities are shown on the plans. However, during the time interval from plan completion to contract award, mother nature or men may have caused changes in the existing drainage course. Therefore, culverts and other drinage facilities, as planned, may not be in exactly the correct position. It is a good idea to make a thorough review of the existing drainage course compared with the location shown on the plans. Profiles of existing drainage are to be taken if there is any doubt whatsoever.

Existing culvert or storm sewer flow lines through adjacent highways, railways, or other facilities may effectively control the flow of water through the intended construction zones. Drainage facilities through the new road bed may require adjustment to conform to in place drainage facilities. ALL DRAINAGE MUST HAVE AN OUTLET. Good drainage and good design of drainage facilities is truly a science, but common sense and good judgment are an absolute necessity if water is to be properly drained without causing property damage, floods or undue erosion.

32.02 Pipe Culverts

Almost every culvert must be staked and installed before grading can begin and the staked length must be known so the contractor can order a reasonably accurate quantity. Although the location, type, size, length and elevation of flow line are shown on the plans, all conditions affecting these requirements should be checked before the culvert is staked. Any major change must be authorized before installation. Culverts should be staked and the staking information made sufficiently clear so there will be no error on the part of the contractor or inspector due to misunderstanding. Skew angles, as shown on the plans, should correspond with field conditions, but if they do not, corrections must be made so the installation will conform with field conditions.

The staked length of culvert pipe must fit the slope and generally, should conform to a multiple of the commercial length available for that size of pipe. A hub and tack is to be set at each end of the pipe centerline a sufficient distance beyond the construction limits to prevent their destruction. A guard stake placed over each hub and tack should show the cut or fill to flow line and the distance offset from the end of the culvert. Other information relative to the length, type and size of pipe needed for instllation, may also be shown on the guard stakes. After the stakes have been set, a check should be made of the total fall and direction of flow, a gradient of 0.3% is generally the minimum grade that will carry sediment. The culvert flow line elevation (invert) should be staked about 0.2 feet lower than the flow line elevation of the inlet and outlet channels to help minimize piping, obtain a more solid bedding and provide more of an opening for small flows.

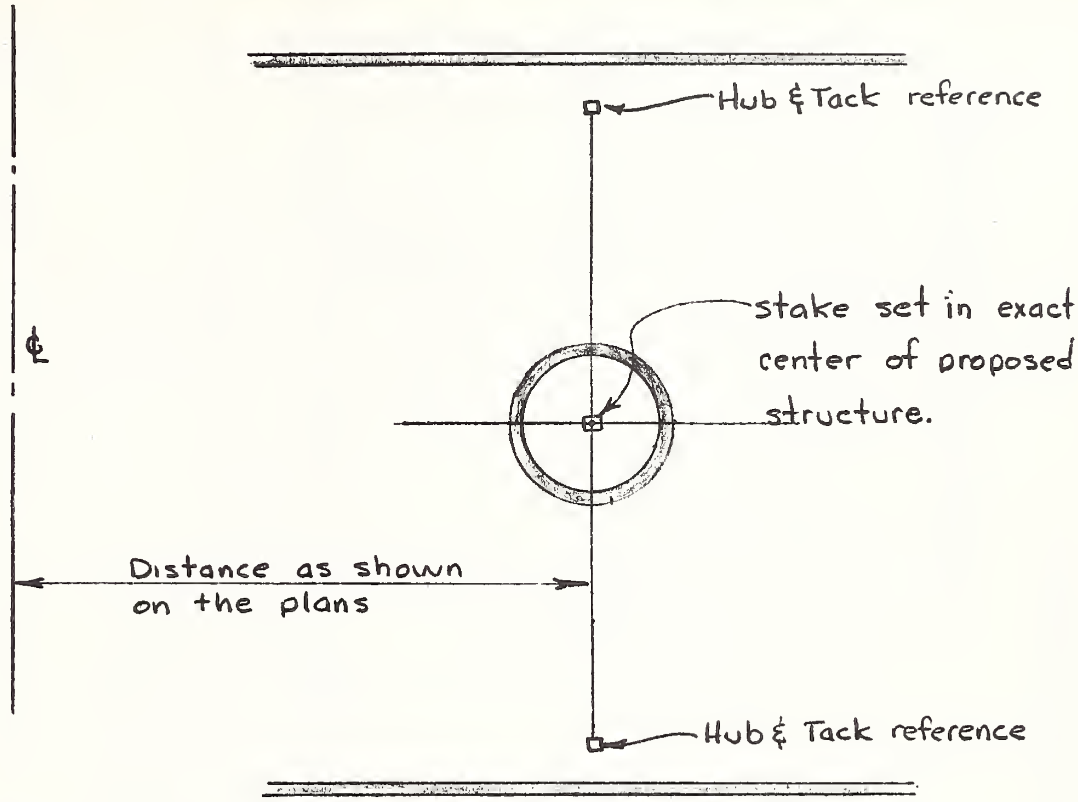
32.03 Concrete Box Culverts (Fig. III-7)

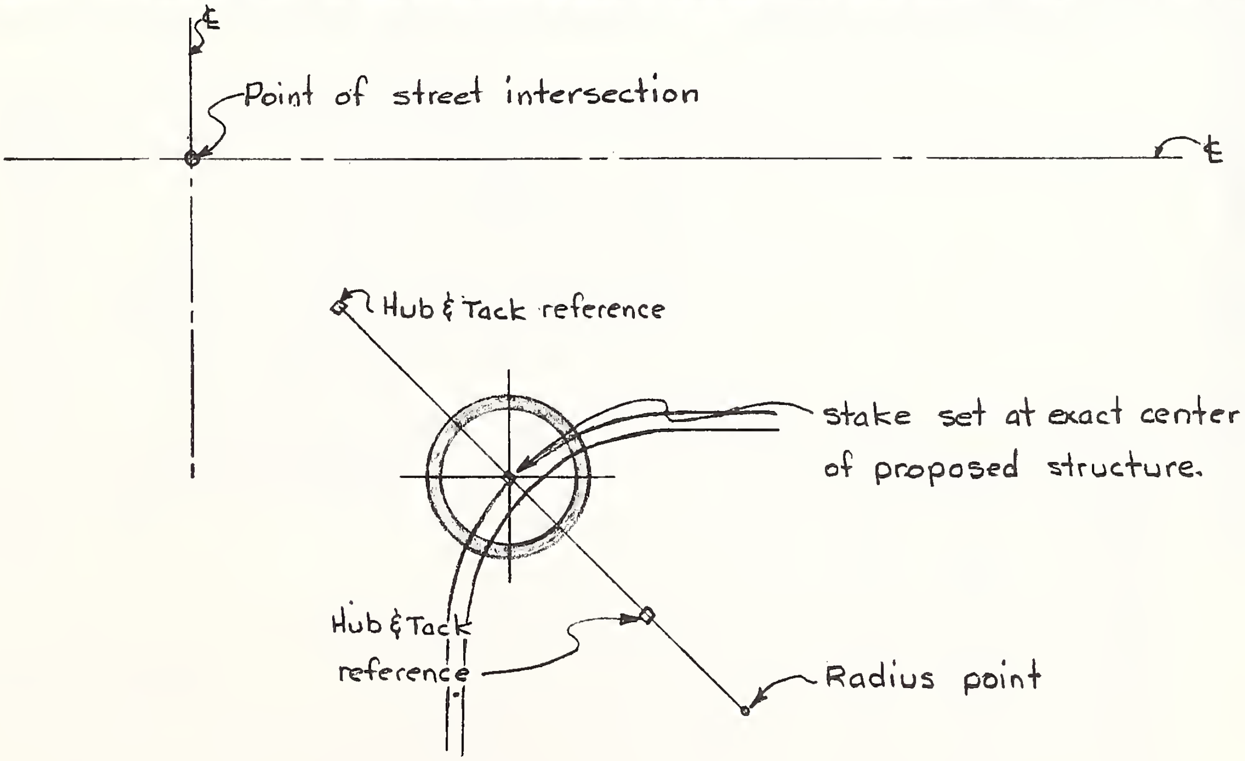
Although the use of concrete box culverts is quite limited, when a concrete box culvert is encountered, the following guides should be followed. The plans of concrete box culvert installation should be thoroughly studied and checked before any firm stakeout is made. The initial staking of box culverts is made on reference lines set parallel to the centerline of the structure. Hub and tack references placed sufficiently outside of the construction zone should be set at each end of the centerline and at convenient locations on the other reference lines run. The need for reference lines will be up to the judgment of the Project Manager but is based primarily on the width, length and location of the box culvert. The culvert centerline and a reference line to the face of wingwalls should be staked. Set finish grade stakes after excavation to the footing elevation. After the footing is in, the remainder of the structure layout can be easily marked by the contractor and checked by the inspector providing that a number of reference elevations are available and alignment is provided. The staking method should be carefully explained to the contractor and the inspector by the Project Manager. It is not adequate for the Project Manager to assume that his inspector has all the necessary knowledge and skill to properly inspect an installation. For example, planned elevations referred to certain portions of the structure may be ambiguous, since the planned elevation or the bottom of the footing may change because of subsurface or construction conditions. In such instances confusion and mistakes may be avoided if the reference stakes are simply marked for the elevation of the reference itself and the meaning of these references explained to the inspector.

32.04 Dikes and Ditch Blocks

Dikes will usually follow the roadway shoulder line to curving or parallel alignments, therefore, stakes marking the extremities of the dikes are usually satisfactory. An adequate number of stakes should be set to delineate all of the features of the dikes and to allow an accurate computation of the earthwork volumes involved.

STAKING OF MANHOLES, CATCH BASINS & INLETS


Hub & Tack reference
stake set in exact center of proposed structure.
℄
Distance as shown on the plans
Hub & Tack reference

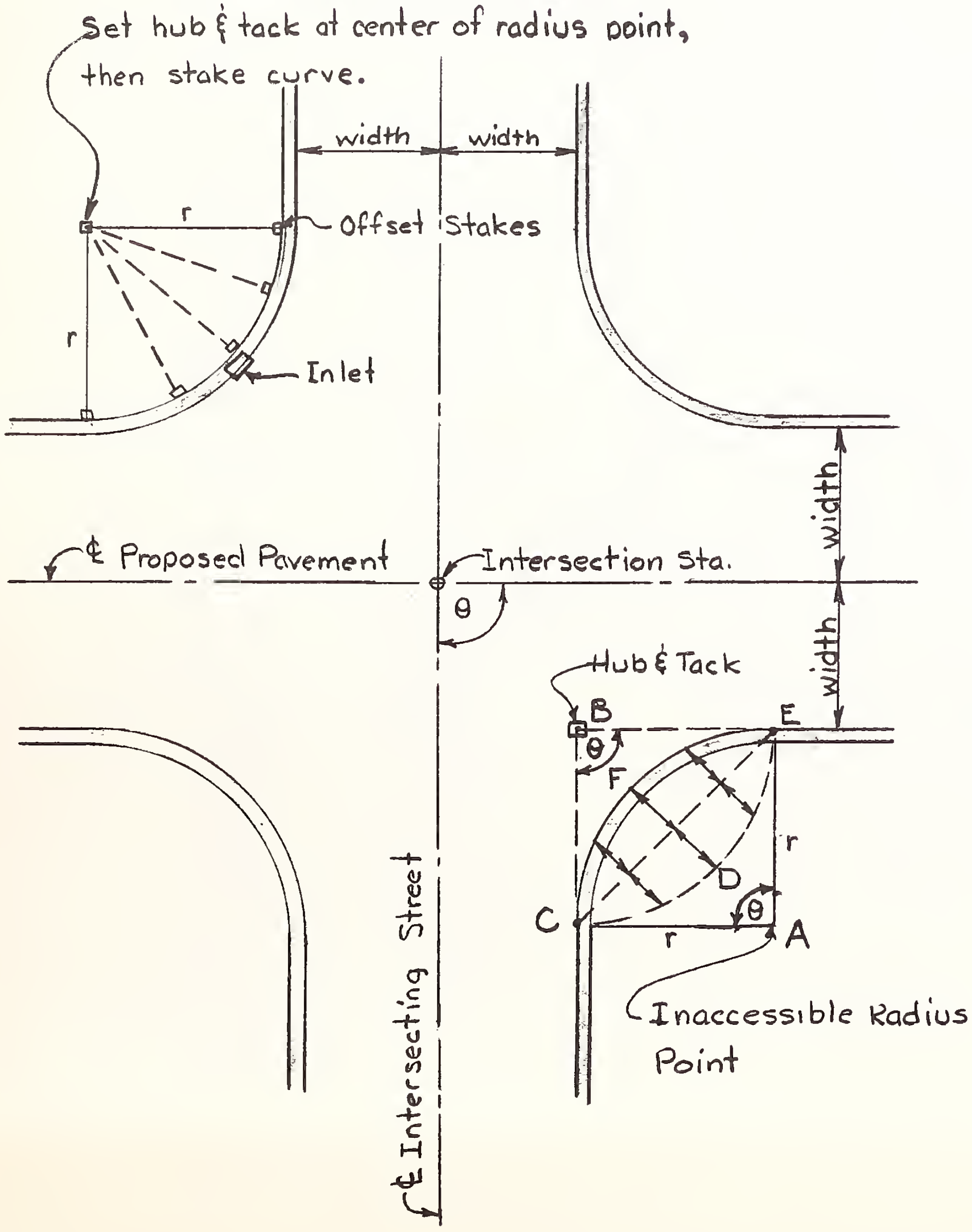

℄
Point of street intersection
℄
Hub & Tack reference
stake set at exact center of proposed structure.
Hub & Tack reference
Radius point

Mark reference stakes with the exact distance to the center of the structure. Cut to the flow line & cut or fill to the finished surface of the structure.

Fig. III-5

STAKING METHODS FOR CURB RETURNS

Accessible Radius Point



Set hub & tack at center of radius point, then stake curve.

Inaccessible Radius Point

To stake curb returns having an inaccessible radius point, set a hub & tack at point B. Use the same radius and θ as if staking from point A, then stake curve CDE. Curve CFE may then be staked by measuring the offset distances from line CE & setting stakes. These offset distances are the same as the corresponding offsets from line CE to curve CDE.

Formulas For Short Radius Curves (10' chords)

I = angle of intersection

D = degree of curvature (10' chord)

T = tangent distance

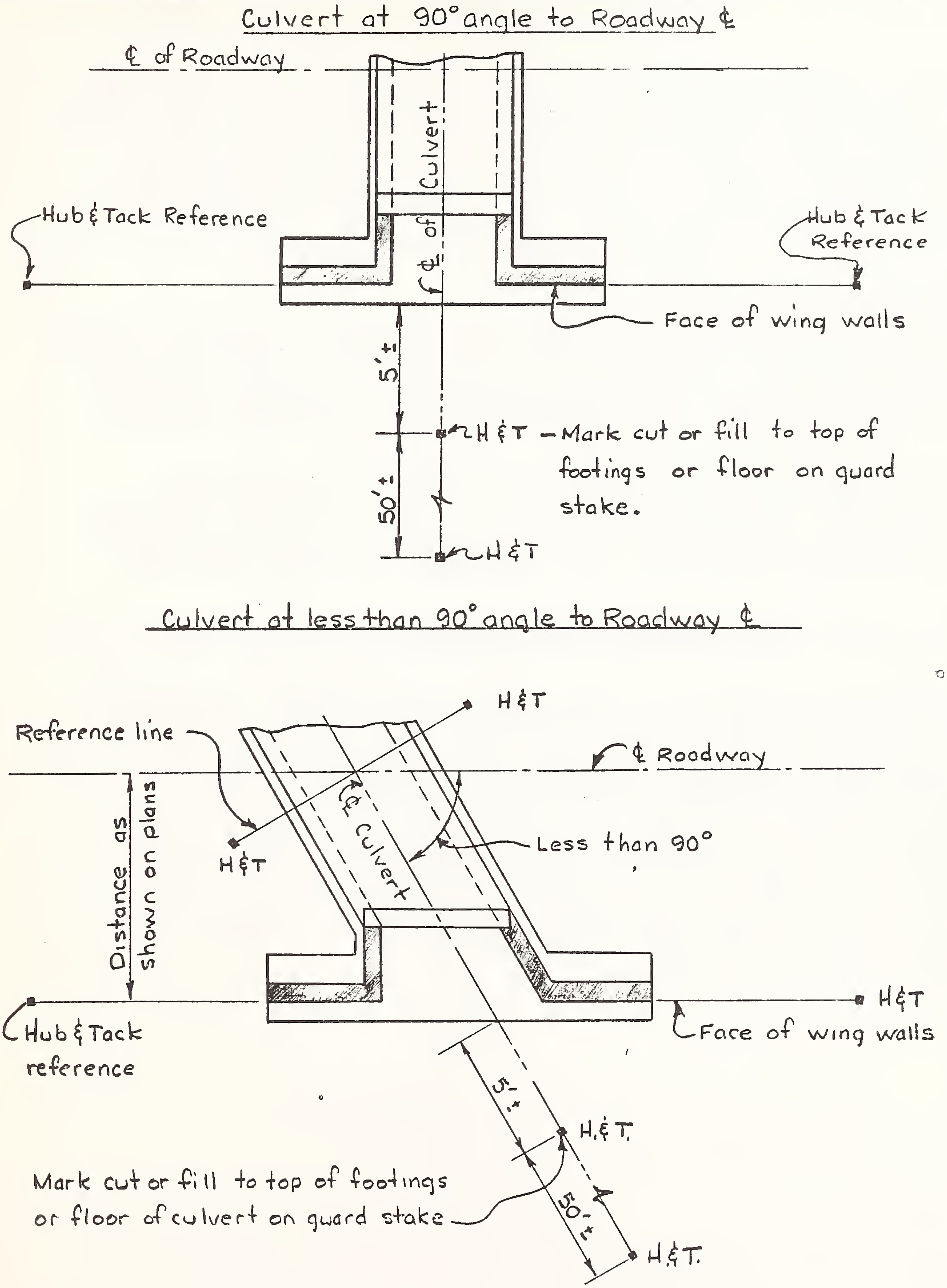
L = length of curve

$$T = R \tan \tfrac{1}{2} I \qquad L = \frac{10\,I}{D}$$

$$R = \frac{5}{\sin \frac{1}{2} D} \qquad \sin \tfrac{1}{2} D = \frac{5}{R}$$

Fig. III-6

STAKING METHOD FOR BOX CULVERTS


Culvert at 90° angle to Roadway ℄

Culvert at less than 90° angle to Roadway ℄

Fig. III-7

Staking of ditch blocks can be done by setting a stake on the shoulder. This stake will then designate the stationing of the ditch black and its height, length and side slopes. The side slopes of the ditch block should start at the inlet or pipe and extend about 10 feet on a slope of 10 to 1 or flatter. The height of the ditch block should be about 1 foot above the top of pipe; be at subgrade elevation; or be about 1' above the inlet elevation.

32.05 Drop Inlets (Fig. III-8)

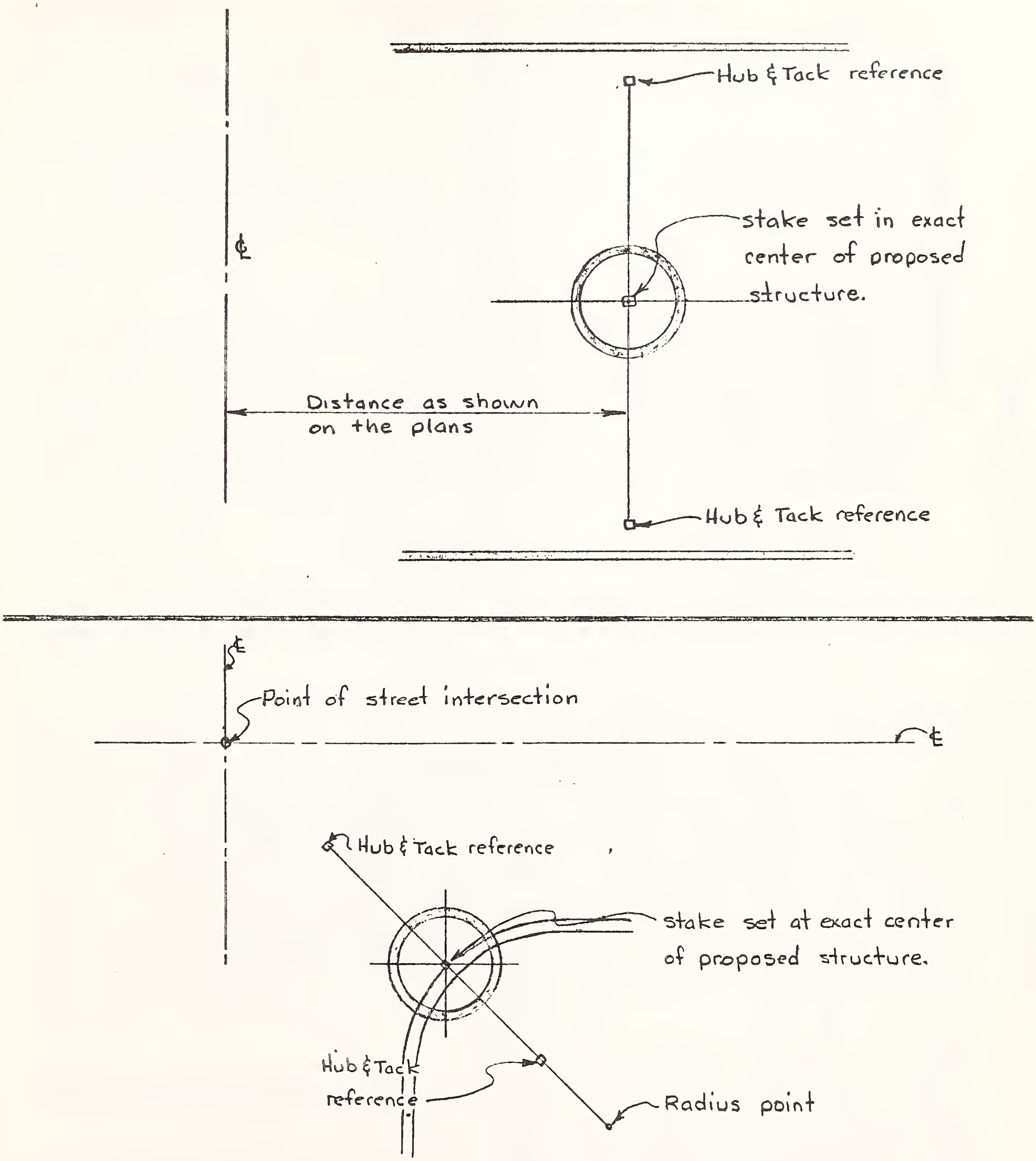
Drop inlets frequently must meet curbs already in place or other in place structures and therefore must be accurately staked to avoid future expensive alterations. There is some flexibility in locating catch basin or curb inlets, but neither of these structures should be placed in the area of a crosswalk.

A single stake, hub or marker may be used to identify the center of the inlet structure and two or more hub and tack reference stakes may be used to establish the structure centerline by marking the distance from the center of the structure to the hub and tack locations.

32.06 Curb, Gutter and Sidewalks (Fig. III-9)

A reference line may be run in back of the curb at a constant offset distance and permanently tied with hub and tacks. Reference distances should be marked to the top, back, or to the flow line of the curb whichever method is convenient and compatible with the construction method intended. The vertical difference in the elevation between the reference point and the elevation of the lip of the curb should be included as well as the cut or fill to grade. The reference line stakes may be set at 25 foot intervals, however, the interval of 50 feet may be used on straight alignment. Such existing grade control points as intersecting streets, in-place sidewalks or in-place curbs and gutter must be used to modify the theoretical planned elevations.

STAKING OF MANHOLES, CATCH BASINS & INLETS

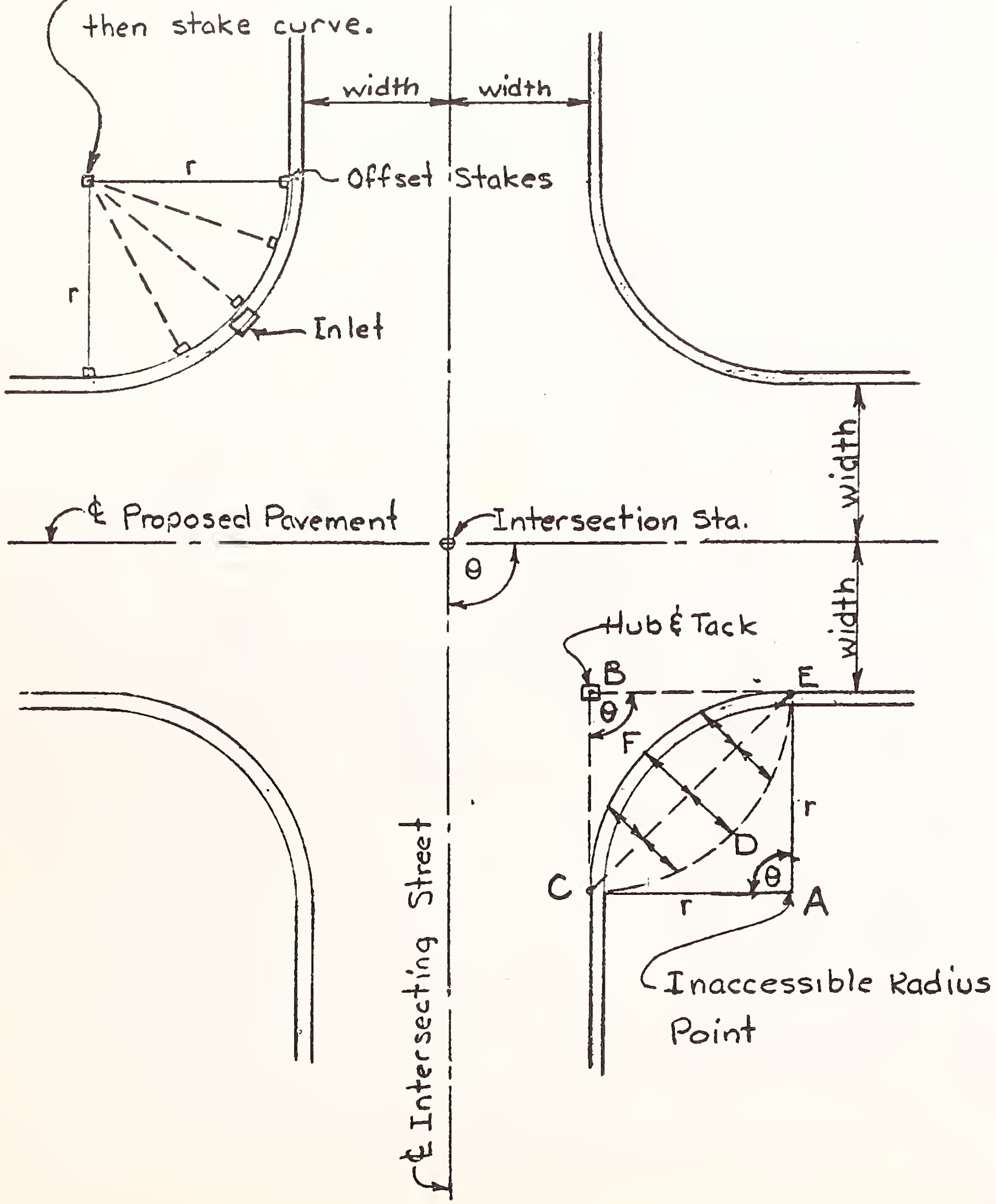

Hub & Tack reference
stake set in exact center of proposed structure.
℄
Distance as shown on the plans
Hub & Tack reference
℄
Point of street intersection
℄
Hub & Tack reference
stake set at exact center of proposed structure.
Hub & Tack reference
Radius point

Mark reference stakes with the exact distance to the center of the structure. Cut to the flow line & cut or fill to the finished surface of the structure.

Fig. III-8

STAKING METHODS FOR CURB RETURNS

Accessible Radius Point



Set hub & tack at center of radius point, then stake curve.

Fig. III-9

Inaccessible Radius Point

To stake curb returns having an inaccessible radius point, set a hub & tack at point B. Use the same radius and θ as if staking from point A, then stake curve C D E. Curve CFE may then be staked by measuring the offset distances from line CE & setting stakes. These offset distances are the same as the corresponding offsets from line CE to curve CDE.

Formulas For Short Radius Curves (10' chords)

I = angle of intersection
D = degree of curvature (10' chord)
T = tangent distance
L = length of curve

$$T = R \tan \tfrac{1}{2} I \qquad L = \frac{10\,I}{D}$$

$$R = \frac{5}{\sin \frac{1}{2} D} \qquad \sin \tfrac{1}{2} D = \frac{5}{R}$$

III-33 CONSTRUCTION SURVEYS FOR MISCELLANEOUS ITEMS

33.00 References

Standard Specifications: Sections 51, 80 through 86, 87 through 90, and 96

33.01 General

The degree of accuracy used in setting construction stakes for miscellaneous items must be consistent with the use of that item and should be adequate to establish the location. Items in this group include, fences, bin walls and retaining walls, traffic control devices, utility items, guardrailing, right-of-way monuments, comfort stations, etc. Some of the items may require a full compliment of stakes precisely set, and other items may only require a mark or a nail placed to indicate correct location.

33.02 Fences

The latest right-of-way map is to be made available for use at the time fences are staked. Last minute changes in right-of-way limits, which may not have been known at the time of original staking, may then be correctly included.

Stakes should be set at the right-of-way line and on right-of-way breaks or curves. Then as a check on accuracy a traverse can be run between these angle points, the angles should be turned to verify the alignment and the traverse closed. Stakes should be set at high points and low points on the right-of-way line so the stakes are intervisible. An adequate number of stakes should be set at a reasonable spacing to allow fence construction without extensive use of surveying instruments. Curved fence alignment may be staked in the usual manner, setting the stakes at regular intervals. Layout of the fence line, to be consistent with the contract pay item, must be made on a line parallel with the top wire of the fence and extend from end post to end post. This new measurement is intended to verify the actual length of fence in place. Do not permit the tape to sag.

33.03 Bin Walls and Retaining Walls

A satisfactory number of cross sections should be taken from a base line offset to the bottom of the bin or retaining wall. The cut or fill from this reference line may then be calculated to other control points of the bin or retaining wall. Establish reference lines and set control points outside of the construction zone to prevent their destruction but permit these points to be readily re-established after excavation.

33.04 Traffic Control Devices

Signs are to be staked at the location indicated on the plans with a lath, stake or hub indicating the location and identifying the sign. The planned position may be moved a few feet one direction or another when obstacles are encountered but care should be taken in positioning signs so they are properly visible and will serve their intended function. Signs may be moved greater distances (10 feet or more) when their visibility will be impaired by trees, buildings, land forms or other permanent obstacles after approval is received from the Division Construction Supervisor, FHWA Engineer, or Construction Bureau. The severity of the move will dictate the need for consulting higher authority.

The Traffic Design Unit will furnish technical assistance, if needed, on projects containing such bid items as permanent signing, traffic signalization or lighting. The Project Manager may request such assistance from the Division Construction Supervisor, through his superiors. In contrast with signs set in rural locations that may be moved to better fit field conditions, a lighting or signal project is intended to function at a specific location and has its structure design for that location only. Therefore, changes in the design or location; even though these changes may be needed and will obviously fit, must receive the attention of the Traffic Design Unit via the Construction Bureau.

33.05 Utilities

Most utility moves, relocations or readjustments are made by the utility owner prior to construction, which will generally confine the staking required by state forces to that necessary for establishing horizontal and vertical clearance controls. Utilities that are being installed, relocated or readjusted as a part of the contracted work will require staking necessary to provide alignment and grade in addition to horizontal and vertical clearance controls. A careful review should be made of the proposed roadway construction so that adequate clearance is provided across road approaches, and the main line, so that the intended position of the utility does not conflict with use of other facilities.

A full survey party should not be used if one or two persons can do the job adequately. With proper handling and advance coordination, most of the utility relocation features can be set to allow a minimum amount of resurveying.

33.06 Guard Rail

Special installation instructions are shown on the plans and on the standard drawing sheets for locating guardrail and guide post installations but it is difficult for a designer to accurately pinpoint these facilities. Therefore, it is necessary to perform a field check of these locations just prior to staking. Adjustments may be necessary in the lengths and locations. The Project Manager should obtain the proper authorization before proceeding with staking when large differences in quantities are encountered.

Several different staking techniques have been successfully employed in the past. The choice of which to use will be determined by the Project Manager. Hubs and tacks or nails set for proper alignment and grade may be placed directly on line or may be offset. Parabolic flares may be established from the offset line. Guardrail on tangents may be staked by marking each end of the run of guardrail or the location of each post on a tangent run may be staked individually. No matter what staking method is used, the Project Manager should insist on a product, that when finished, presents a satisfying appearance in alignment and grade.

33.07 Right-of-Way Monuments

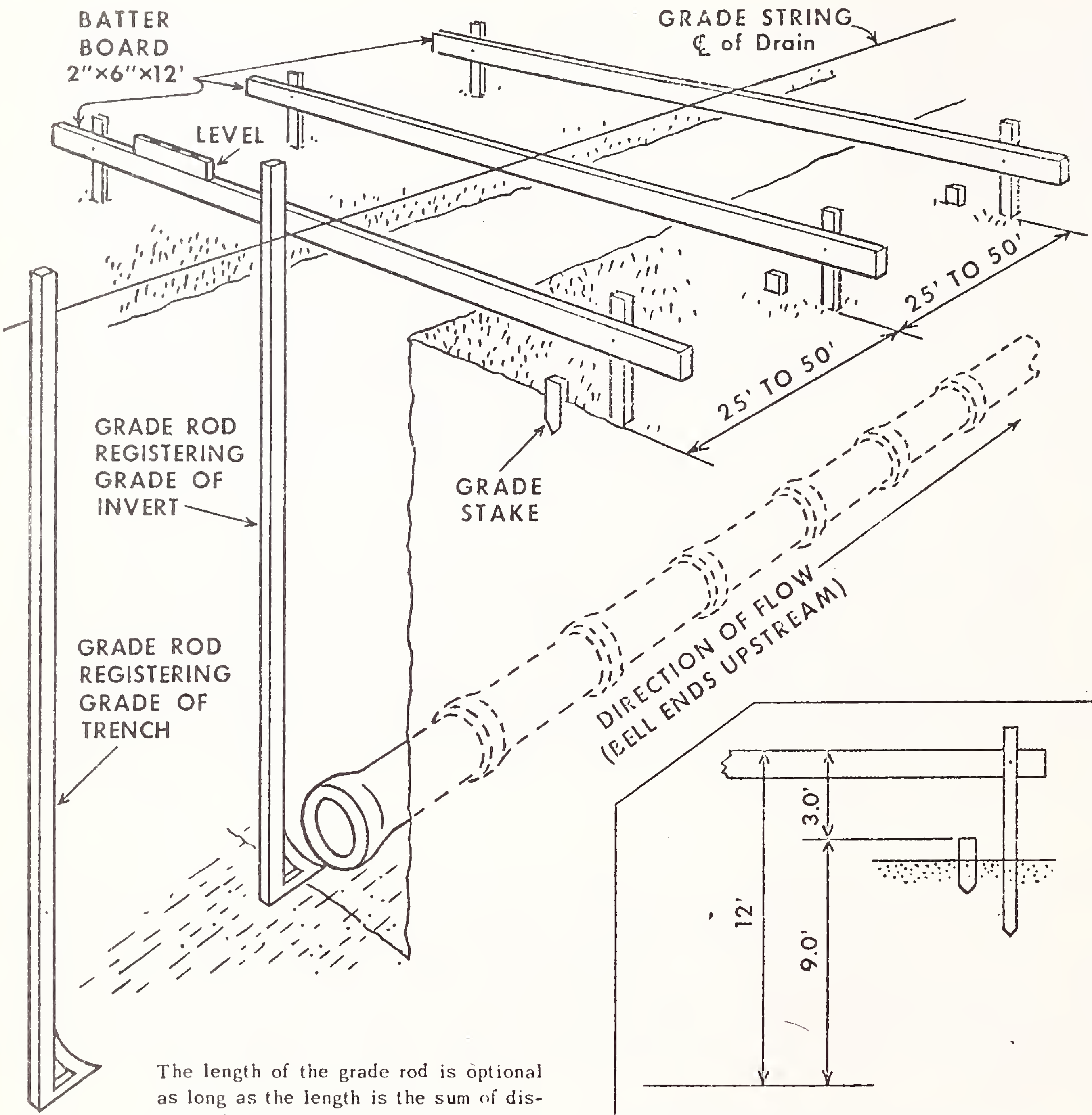
Right-of-way monuments are to be staked at the locations shown on the plans and those locations referenced by the use of hubs and tacks and an iron pin. The back face of the right-of-way monument is to be set on the right-of-way line. The location of the hubs and tacks, iron pins and changes in right-of-way widths are to be detailed and dimensioned in the transit notes. A separate notebook will then be set up during construction to show the final location of all right-of-way monuments and their referenced ties to centerline or witness markers.

33.08 Comfort Stations

Staking of comfort stations involves an entirely different concept other than the regular route surveying done by highway engineers. Prefabricated materials are used extensively in the walls and partitions of the building. Drain fields are needed, underground sprinkling systems may be required and such surface facilities as driveways, sidewalks and locations for planting trees and shrubs are sometimes a necessity.

A careful review of the plans for the building site and attendant facilities should be made before staking is begun. Base lines or reference lines should be established at the proper locations and their control points referenced to prevent destruction. Line and grade must be set for the footing of the building and sewer facilities and a convenient reference provided for carpenters or other workmen to establish batter boards and other construction aids to fit the line and grade.

METHOD OF STAKING TILE UNDERDRAIN AND SEWER


BATTER BOARD 2"×6"×12'
GRADE STRING ℄ of Drain
LEVEL
25' TO 50'
25' TO 50'
GRADE ROD REGISTERING GRADE OF INVERT
GRADE STAKE
DIRECTION OF FLOW (BELL ENDS UPSTREAM)
GRADE ROD REGISTERING GRADE OF TRENCH
3.0'
12'
9.0'

The length of the grade rod is optional as long as the length is the sum of distance from the top of the stake to the flow line of the tile and from the top of the stake to the top of the batter board.

The illustration shows an 8 ft. grade rod, the cut on the grade stake is 5.0' to flow line of tile. 8' - 5' = 3'. Therefore the batter boards will be set 3 ft. above grade stake.

EXAMPLE GRADE BOARD SET-UP:

CUT TO SEWER INVERT FROM STAKE = 9.0'

A 12 FOOT GRADE BOARD IS CHOSEN

12.0 — 9.0 = 3.0

THE BOARD IS THEN PLACED 3.0' ABOVE THE STAKE

Fig. III-10

BRIDGE CONSTRUCTION SURVEYS

35.00 References

Standard Specifications: Articles 05.02, 05.03, 05.08

35.01 Responsibilities for Survey Work

This Article separates the contractor's responsibilities and work from those of the State regarding layout and survey work as defined in Article 05.08 of the Standard Specifications.

The intention is to define the method which will provide an independent check of all structure layout. This will be to the mutual benefit of the contractor and the Department of Highways in that delays and expenses incurred due to the improper location of structure units will be held to a minimum. This will also aid in maintaining engineering costs at acceptable levels. It is not the intention to use these instructions as a reason for State personnel to sit idle while the contractor is doing survey work justly the responsibility of the State.

A. Department of Highways Work

Project personnel shall provide the contractor with centerlines and bench marks in accordance with Article 05.08 of the Standard Specifications. The centerline will be marked by clearly identified points set in the immediate vicinity of each structure unit under construction. These points will be in addition to the primary survey controls ordinarily established for references. It is intended that these points be set such that the contractor will be able to proceed with the remaining layout by means not requiring the services of someone especially skilled in surveying i.e., sufficient controls will be set so the contractor can use:

1. Batter Boards
2. String Lines or
3. Simple instrument set up to shoot straight lines from one point to another.

The State shall furnish bench marks which shall include:

1. Cut stakes for footing excavation
2. Beam seat elevations for brush hammer leveling and/or shims
3. Span tenth point elevation for setting deck slab forms.
4. Grade on structural steel splices.

The Department of Highways is responsible for the accuracy of the bench marks and points described above according to Article 05.08 of the Standard Specifications.

B. Contractor's Work Responsibilities

The contractor will be required to complete the remaining layout and to set and maintain the location of excavation, piling, cofferdams, forms, etc. in accordance with these points. This work shall be the responsibility of the contractor.

C. Checking and Inspection Work

It is MANDATORY that the Project personnel physically check the contractor's layout for line and grade on the following items in particular at the stage of work indicated.

1. Cofferdams - When ring is set and prior to driving sheets.
2. Footing excavation - Prior to beginning excavation.
3. Piling - Prior to driving piles.
4. Forms - Prior to authorizing the contractor to order and place concrete.
5. Embedded Items - Prior to authorizing the contractor to order and place concrete.

In some cases it is the best interest of the Department of Highways to perform intermediate checks prior to the above mentioned stages of work i.e. - checking of form locations prior to placing large quantities of reinforcing steel where moving the form would result in a major operation of dismantling, shifting the reinforcement and additional structure excavation. Discretion should be exercised in making such checks so they do not become a substitute for the mandatory checks described above or become a substitute for the layout that is the contractor's responsibility.

It is recognized that occasions will arise when demands on Project Personnel will exceed their capacity to perform all required inspection at the particular time desired by the contractor. In these cases, it shall be the RESPONSIBILITY of the Project Manager or the person in charge to require the contractor to set priorities for the work. IN NO CASE will work be allowed to continue without the required inspection.

The need for additional inspection personnel and/or more efficient procedures and scheduling is indicated if it becomes necessary to continually set such priorities.

PLEASE CALL SPECIFIC ATTENTION TO BRIDGE CONSTRUCTION STAKING AT ALL PRECONSTRUCTION CONFERENCES.

35.02 Preliminary

A. Check dimensions on bridge plans prior to staking. Particularly check elevations from finished grade down through deck slab, girder, shoes, crossbeams, columns and footings. Check span lengths, skew angles, etc. for horizontal control.

B. Review road or other plans for construction features that could affect the layout and location of references for the structure; and discuss any special embankment requirements with roadway Project Manager.

C. Check alignment and stationing of roadway centerline as staked in field. Be certain that lines and stations already staked on the ground are as shown on the plans.

D. Determine if bench marks as shown on plans and proposed for establishment of vertical control are in place and usable.

E. Plan layout and referencing to provide control of work with required accuracy in the most economical manner. Place references where they will serve the intended purpose for as long as required; where they are readily usable; and where they are secure from construction operations. (If such is possible). That is, do not place references in center of projected ramp road, or in a place where a portion of substructure will not be visible.

F. BEFORE construction work may begin on any structure, layout, referencing and field checking of primary horizontal and vertical control must be complete.

35.03 Horizontal Control - General

Due to terrain conditions and other considerations at each site, it is not practical to rigidly adhere to any one standard method of layout and referencing. Figure No. 1 through No. 5 are intended for examples of minimum acceptable methods. When it is necessary to vary from these methods, the following basic principles of good engineering practice shall be adhered to:

1. Methods of distance and angular measurement will be used to produce work that is within the following permissible limit of error:

   a. Cast in place structures - 1/4"/100' or 1 in 5000

   b. Prestressed beam structures - 1/8"/Span or 1 in $\frac{\text{Span Length}}{0.01}$

   c. Steel Structures-1/8"/Span or 1 in $\frac{\text{Span Length}}{0.01}$ (Centerline Brg to Centerline Brg)

   Example: 50' Span Accuracy required = 1 in 5000

   100' Span Accuracy required = 1 in 10,000

   200' Span Accuracy required = 1 in 20,000

2. LAYOUT SHALL BE CHECKED BY A METHOD INDEPENDENT OF THE METHOD USED INITIALLY. This will be entered in a set of notes clearly showing the method of checking used, all computation, observed errors and the accuracy of original work as compared to check.

3. Reference points should be established by methods which will permit the re-establishment of the layout to the original accuracy.

4. References will be established in sufficient numbers, in the proper locations, to permit accurate and timely control of the work.

5. Reference points will be clearly identified and flagged on the ground. Notes shall be prepared such that a person not familiar with the project will be able to readily locate and use the reference system and re-establish points destroyed or disturbed. RECORD LAYOUT AND REFERENCES IN FIELD NOTES.

6. At least one line of reference, located beyond the outermost portion of substructure units, should be established to permit a check of span lengths along the reference line to detect divergence from plan lines.

35.04 Horizontal Control - Tangent Dryland Structure

A. Preliminary - Check instrument for accuracy. Adjust if necessary. Standardize chain, if possible, for various conditions of use.

B. Procedure - See Figures 1, 2 and 3.

1. Establish centerline of structure, centerline of roadway or other control line as required. Reference this line with two (2) points on either end of bridge. Witness points outside construction limits,

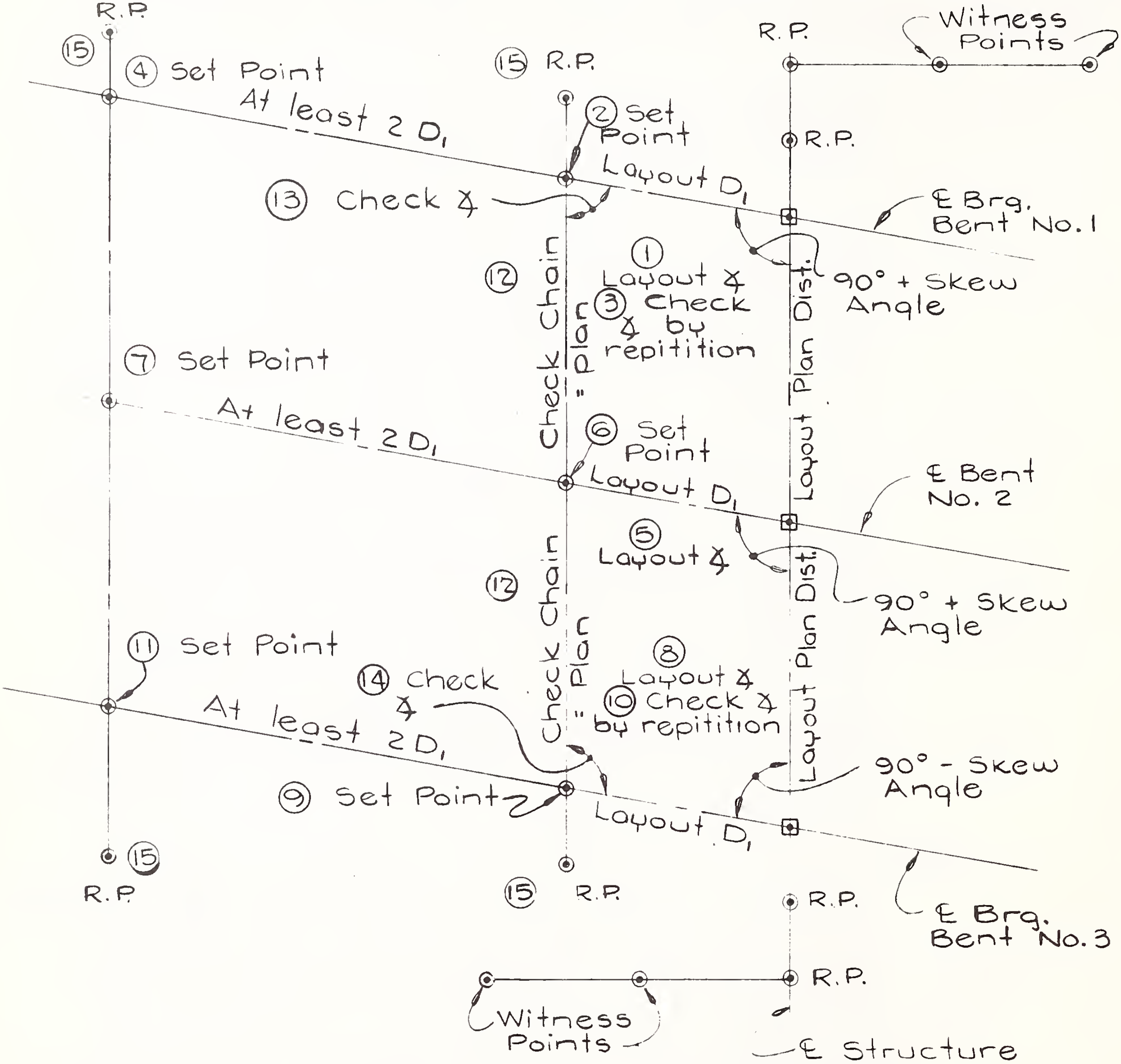
2. Establish points at the intersection of centerline of structure, etc. with centerline of bearing or centerline of Bent of all the various units of the substructure. Place guard stakes on these points clearly identifying them. Example: Bent No. 2 Westbound - Centerline of Bent at Centerline of Roadway - Station 484+75.00.

3. Reference the points established in (2). See Figures No. 1 and No. 2 for reference layouts. Use method of turning angles and chaining distances consistent with accuracy required. Separate references a distance sufficient to minimize effects of normal sighting and instrument set-up errors. Clearly identifying the reference points on the ground. Include the following: (a) Line referenced. (b) Bent No. (c) Distance from centerline of structure. Record reference points in notes. Include information such as distance from centerline of structure, topography useful to approximately locate points, (ties), relationship to structure and type of point set.

4. Perform independent check of layout. Enter in notes a sketch of method used, computations, observed errors, and errors expressed as a ratio. See Figures No. 1 and 2 for examples. On skewed structures, provision should always be made to allow check chaining of span lengths at a reference line outside of the outermost portion of the bents. (See Figure No. 3). This is a necessary check to assure that the bent centerlines are not incorrectly diverging or converging.

5. Steps 1, 2, 3 and 4 constitute the primary control and must be performed before construction begins on any portion of the structure. If construction is allowed to proceed on a portion of a structure before these steps are accomplished, it becomes extremely difficult to complete the layout in accordance with good practice.

PRIMARY CONTROLS - GRID REFERENCE SYSTEM



② Indicates sequence

⊙ Reference point

Angle checks:

∡③ + ∡⑬ = 180° 00′

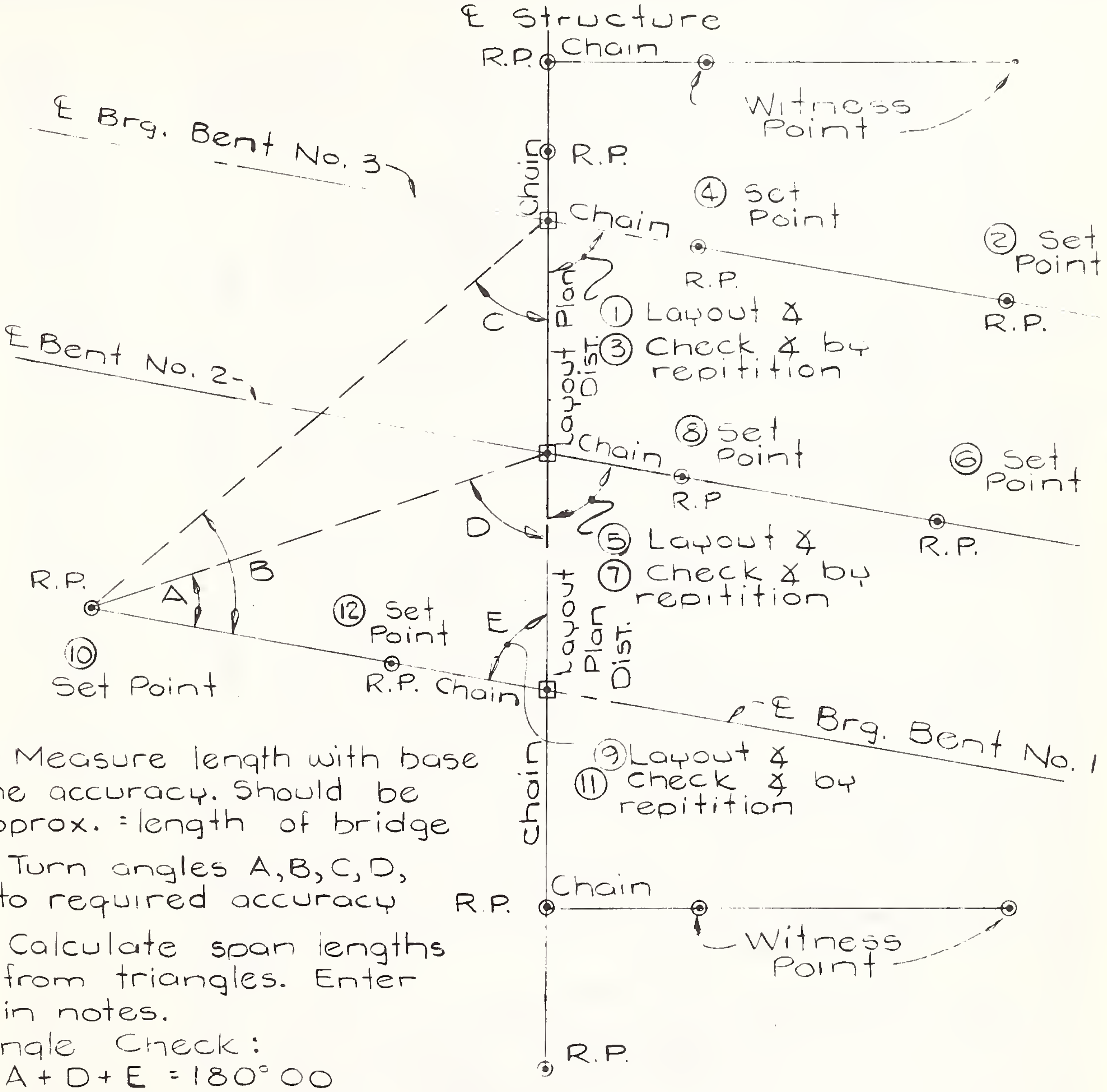
∡⑩ + ∡⑭ = 180° 00′

∡③ + ∡④ + ∡⑩ + ∡⑭ = 360° 00′

Note: This method provides independent checks of chaining, angles and convergence or divergence of bearing lines. Show reference system in notes with lineal and angular errors found in checks.

FIGURE No. 1

PRIMARY CONTROLS - RANDOM REFERENCES & TRIANGULATION



⑬ Measure length with base line accuracy. Should be approx. = length of bridge

⑭ Turn angles A, B, C, D, to required accuracy

⑮ Calculate span lengths from triangles. Enter in notes.

Angle Check:

A + D + E = 180° 00

B + C + E = 180° 00

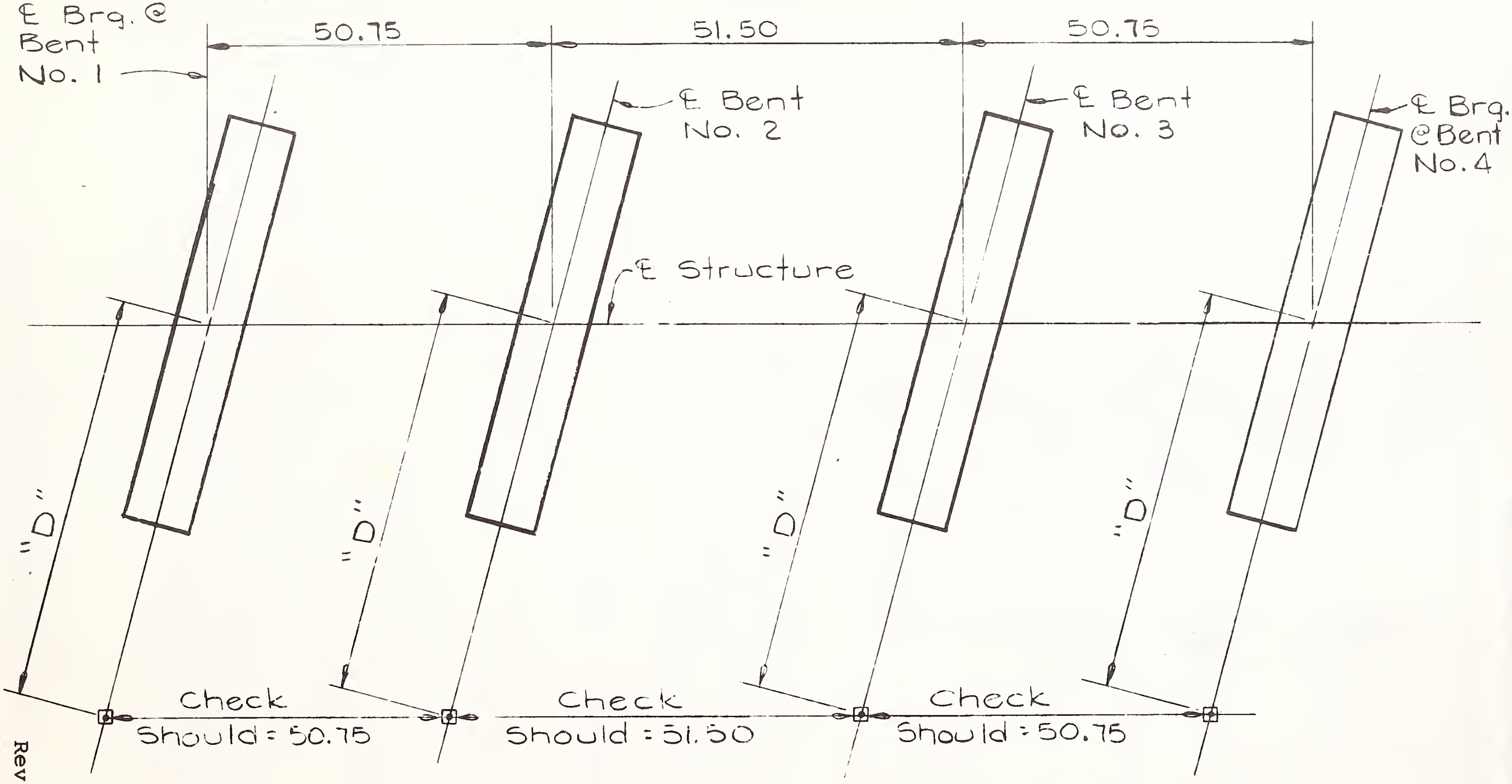
⑯ Calculate lineal & angular error & enter in notes with sketch of primary controls references.

Note: The above system illustrates the minimum acceptable primary controls. If possible set one R.P. per bent at same distance from ℄ structure on same side and check chain between to ensure bent lines are parallel.

FIGURE No. 2

Rev. 5-1-73

CHECK OF SKEW ANGLES & REFERENCE LINE



Note: This relatively easy check will determine if the skew angles laid out are parallel to each other and not converging or diverging. The hubs and tacks placed for this may be utilized for construction controls.

FIGURE NO. 3

6. Should the situation arise out of absolute necessity, the following procedure shall be used to allow construction before all primary controls have been established.

   (a) Establish the location of one sub-unit (bent, pier, abutment, etc.). This sub-unit becomes the anchor point for the layout of the rest of the structure.

   (b) Proceed with layout of rest of structure by direct measurement from anchor point sub-unit.

   (c) The use of this method requires that establishment of construction controls proceed in order from the substructure unit first located.

   (d) This method requires that direct measurement be made to check each new substructure unit against those already constructed.

   (e) This procedure shall also be used in instances where primary controls can not be re-established due to having been destroyed or disturbed during the course of construction.

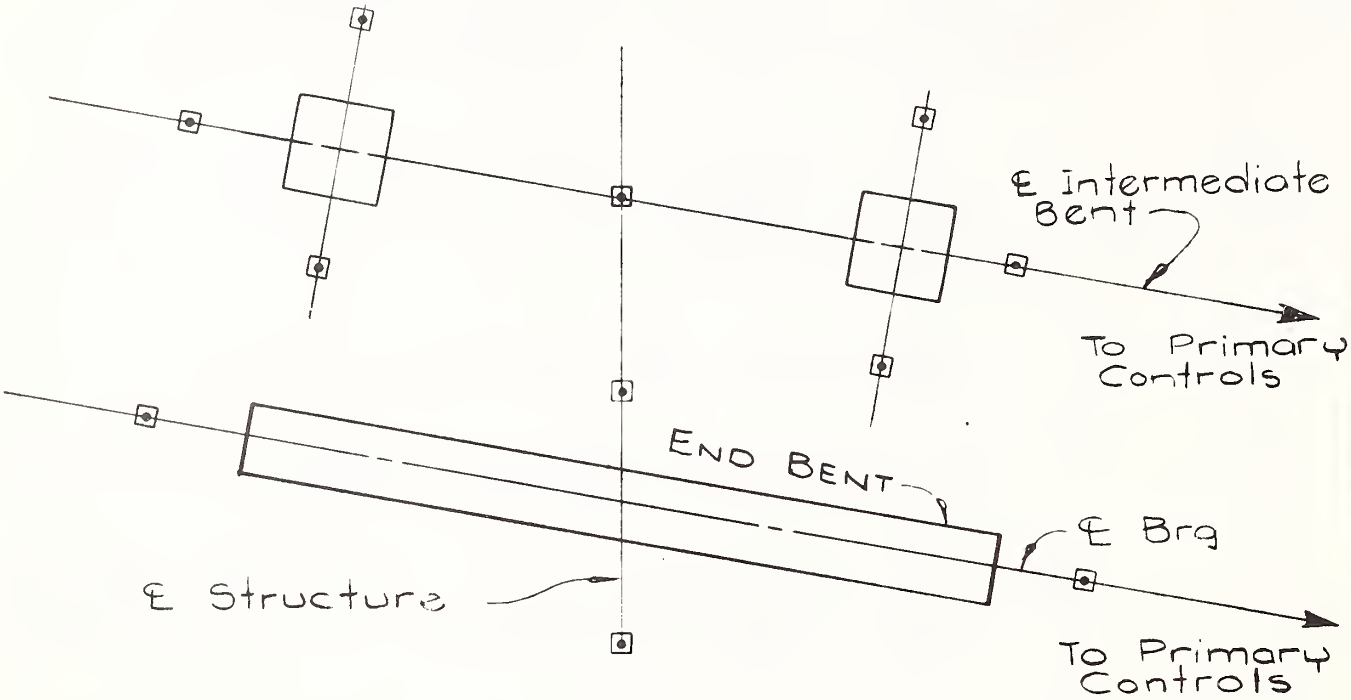
7. If check shows that layout and references are within limits of permissible error, proceed with layout of construction control points. In the interest of consistency and uniformity and in keeping with policy, the following procedure for establishing construction control points is recommended. (See Figure No. 4).

   (a) Layout and establish points on centerline of footings, abutments, sufficient to permit the contractor to locate footing excavation limits, layout piling, set footing and column forms, etc. by means of batterboards and string lines or other means as he may choose.

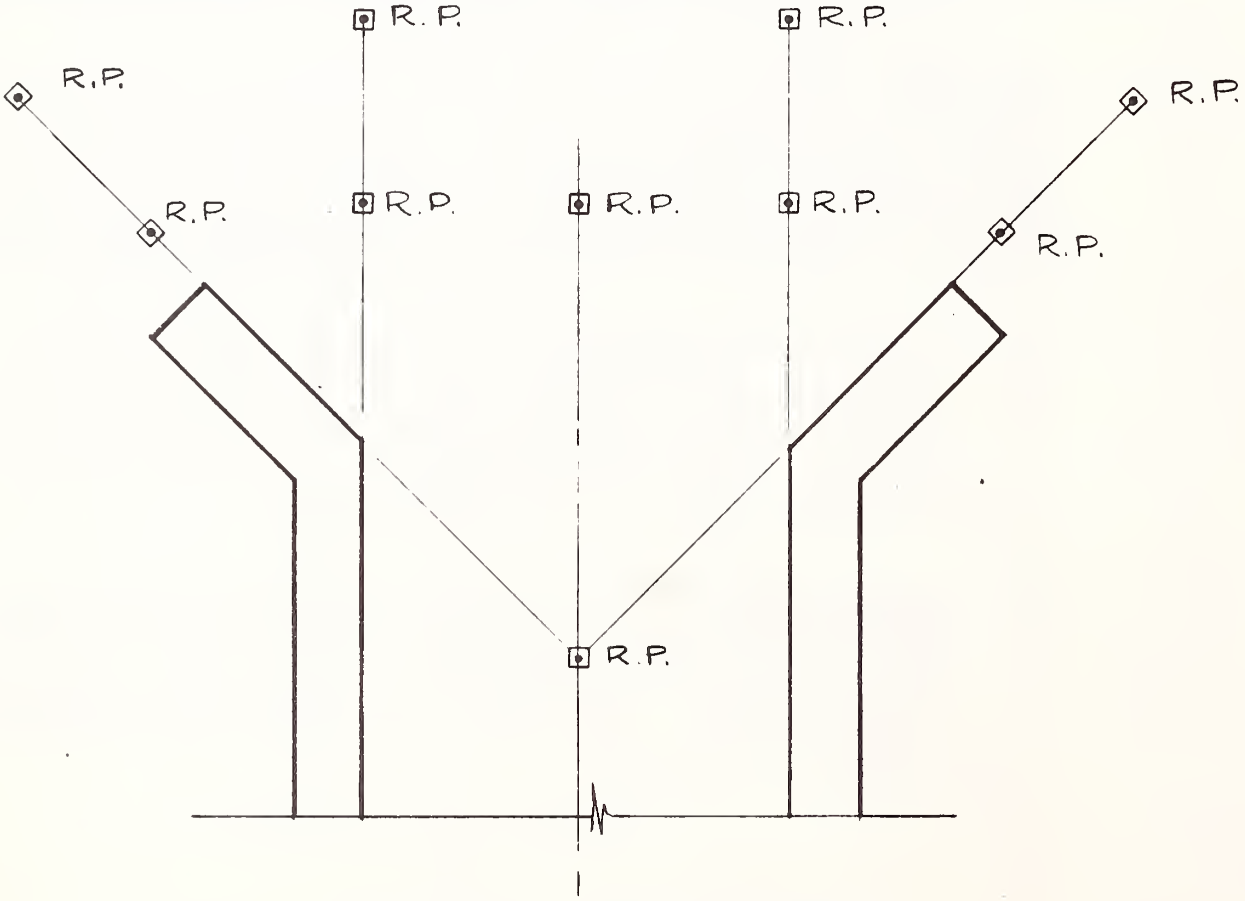
   (b) It is required that the contractor lay out footing excavation limits, piling, set forms on line, etc. from the points furnished. His layout shall then be checked by the State crew prior to placement of the items. This will result in an independent check of the work.

CONSTRUCTION CONTROLS

TYPICAL GIRDER STRUCTURE



JUNIOR GRADE SEP., RET. WALL, BOX CULVERT



TYPICAL BOTH ENDS

FIGURE NO. 4

(c) After the first substructure unit has been constructed, the location of subsequent units should be checked in reference to previously constructed units by careful direct measurements to insure proper fit of superstructure work. This is particularly true for crossbeams. Measurements should take into account the effects of slope, temperature and tension.

35.05 Horizontal Control - Dryland Structure on Curve

1. Establish bridge chord or other control line as required. Reference with two (2) points on either end of bridge. Witness points outside of construction limits as necessary to permit re-establishment of line.

2. Establish points at intersection of bridge chord or control line and centerline of bearing or centerline of Bent. Identify these points with guard stakes and in notes with same information as structure on tangent. See Section 35.04 B 2.

3. Reference the points established in 2. See Figure No. 1 and procedure outlined in Section 35.04 B 3. In making layout it will be necessary to perform computations for various distances to utilize the system shown; however, use of this system will result in an independent check of angles and of span distances on centerline and at the reference lines.

4. ALWAYS PERFORM INDEPENDENT CHECK OF LAYOUT. Follow procedure as stated in Section 35.04 B 4, B 5, B 7 for tangent structure.

5. Pay particular attention to offset distances from chord line to centerline of Bent or centerline of footing. Check plan distances in office on paper prior to layout and check completed field layout. Layout errors in this are very common.

35.06 River Crossing - Triangulation (See Figure 5, 6, 7, 8, 9, 10)

The following procedure will be used in staking all river crossings, and all other structures where the width of the stream, rough terrain, or other conditions prevent direct measurement on centerline by ordinary chaining methods to the necessary degree of accuracy.

1. Preliminary - Check instrument for proper adjustment. It is absolutely necessary to standardize the chain used for base line measurement.

TRIANGULATION FOR INACCESSIBLE STRUCTURES

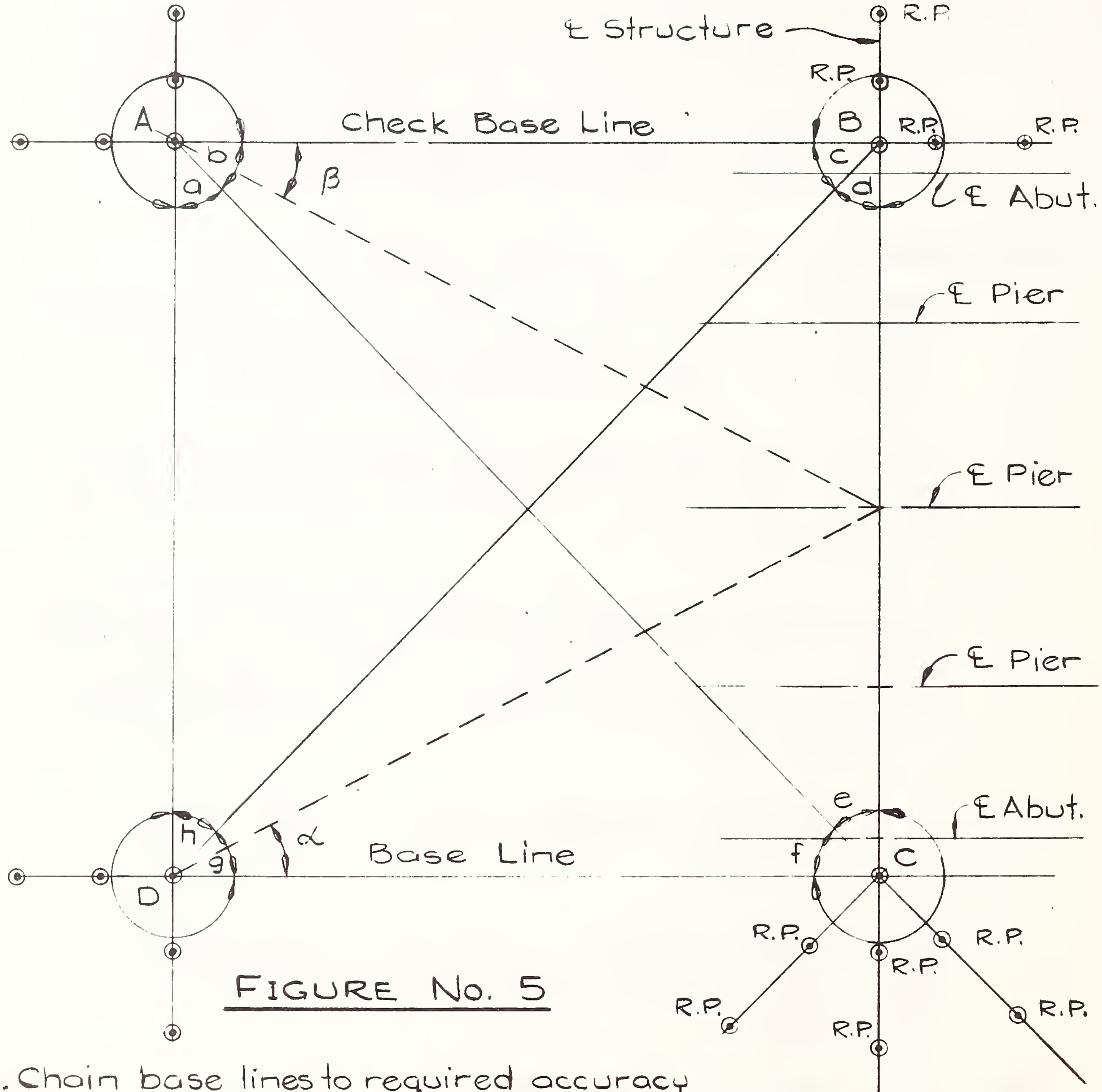


FIGURE No. 5

1. Chain base lines to required accuracy
2. Turn all angles to required accuracy both interior & exterior (Close horizon)
3. Make station adjustments to 360°
4. Make triangle adjustments to 180°
5. Adjust quadrilateral
6. Compute all sides
7. Solve for check base measurement & compare with actual.
8. In case where not possible to direct chain from pier to pier solve for α & β angles to locate.
9. Locate piers with angles if necessary. Best to use 2 instruments. Check location by sighting along ℄ Structure.
10. Proceed with referencing & construction layout to extent possible.

EXAMPLE

Angle	∠ x 1	∠ x 12	Average ∠
Transit @ Sta. A			
a	46° 07' 00"	553° 22' 00"	46° 06' 50"
b	53° 46' 00"	645° 13' 00"	53° 46' 05"
outside	260° 07' 00"	3121° 22' 00"	260° 06' 50"
Transit @ Sta. B			
c	48° 08' 30"	577° 40' 00"	48° 08' 20"
d	42° 17' 00"	507° 24' 00"	42° 17' 00"
Outside	269° 34' 30"	3234° 55' 00"	269° 34' 35"
Transit @ Sta. C			
e	35° 49' 00"	429° 50' 00"	35° 49' 10"
f	54° 03' 00"	648° 36' 00"	54° 03' 00"
outside	270° 08' 00"	3241° 35' 00"	270° 07' 55"
Transit @ Sta. D			
g	47° 51' 30"	574° 15' 00"	47° 51' 15"
h	31° 59' 00"	383° 49' 00"	31° 59' 05"
outside	280° 09' 30"	3361° 54' 30"	280° 09' 32.5"

FORM CSN-02

FIGURE No. 6

2. Locate the points for establishing the centerline of the structure. Make certain that the line and the stationing staked on the ground are in agreement with the plans.

3. Set two points on centerline of structure as near the two bridge ends as possible. These should be chosen to permit inter-visibility with all other triangulation points and to permit ready layout of substructure units.

4. Establish Base Lines - These should be chosen such that the base line and the check base line are nearly equal to the length to be measured and such that the interior angles of the triangles are approximately 60°. Where necessary, stake intermediate chaining points and supports. Be particularly careful to make intermediate chain points solid. Line points with transit. Provide supports at 20' intervals on straight line grade between intermediate chaining points. It is desirable to fasten a soft metal cap (aluminum) on the intermediate chaining points to permit scribing of lines for measurement rather than using tacks. Determine and record the elevation of the chaining points for calculation of slope correction when necessary.

5. Chain base line. A minimum of three measurements shall be taken on each base line. Personnel should be alternated so distance, temperature and tension are read by a different person for each complete base line measurement. Equipment necessary will include standardized chain, chain scale and chain thermometer. Record in notes chain tension, temperature and difference of elevation for each interval of base measured. Compute and apply temperature and slope corrections. Calculate probable error of base line. Consult a surveying text book for method of calculation.

6. Measuring angles - For accurate measurement of angles, the transit and targets must be centered over the points and stable supports used for the plumb lines or targets. Hand held plumb lines will not give acceptable results. Turn each interior and exterior angle at each triangulation point. When transit is used, turn each angle at least six (6) times with instrument direct and with instrument inverted to produce desired accuracy. See table below for example: (Table on following page)

No. of Repetitions	Limit of Possible Error
1	± 0° 00' 30"
2	± 0° 00' 15"
3	± 0° 00' 10"
4	± 0° 00' 07.5"
5	± 0° 00' 06"
6	± 0° 00' 05"

The precision with which the angle can be measured is not appreciably increased by repetitions in excess of 6. Use of KIAE theodolite will produce a limit of possible error of + 0° 00' 05" with a single reading.

7. Adjustment of Quadrilateral - The adjustment of observed angles of the quadrilateral is made in three steps: (1) The station adjustment, to make the sum of the angles around each point equal 360°, (2) the figure adjustment for the geometric condition that the sum of the interior angles of a rectilinear figure is equal to (n-2) 180°, in which "n" is the number of sides of the figure, (3) the trigometric condition that in any triangle the sines of the angles are proportional to the lengths of the sides opposite.

a. Station Adjustment (Figure 7)

Adjust the angles around each point to make their sum equal 360° by distributing the error equally (or approximately so) among the several angles.

b. Figure Adjustment for Geometric Condition (Figure 8 & 9)

When all angles in a quadrilateral are measured, there are four overlapping triangles. These are shown as triangles ABC, ACD, ABD, BCD in Figure 5. In each of these triangles the sum of the three angles must be 180°. Hence from the figures.

$$b+c+d+e = 180^\circ \qquad (1)$$

$$a+f+g+h = 180^\circ \qquad (2)$$

$$a+b+c+h = 180^\circ \qquad (3)$$

$$d+e+f+g = 180^\circ \qquad (4)$$

STATION ADJUSTMENT

Sta.	∠	Observed Value	Adjusted Value
A	a	46° 06' 50"	46° 06' 55"
	b	53° 46' 05"	53° 46' 10"
	outside	260° 06' 50"	260° 06' 55"
	Sum	359° 59' 45"	360° 00' 00"
		$\frac{15}{3}$ = +5" Correction	
B	c	48° 08' 20"	48° 08' 22"
	d	42° 17' 00"	42° 17' 01"
	Outside	269° 34' 35"	269° 34' 37"
	Sum	359° 59' 55"	360° 00' 00"
		$\frac{5}{3}$ = +2" Correction	
C	e	35° 49' 10"	35° 49' 09"
	f	54° 03' 00"	54° 02' 58"
	outside	270° 07' 55"	270° 07' 53"
	Sum	360° 00' 05"	360° 00' 00"
		$\frac{5}{3}$ = −2" Correction	
D	g	47° 51' 15"	47° 51' 18"
	h	31° 59' 05"	31° 59' 07"
	Outside	280° 09' 32.5"	280° 09' 35"
	sum	359° 59' 52.5"	360° 00' 00"
		$\frac{7.5}{3}$ = +2.5" Correction	

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FIGURE No. 7

GEOMETRIC ADJUSTMENT

∠s a+b+c+d+e+f+g+h = 360°

a	46°	06'	55"
b	53°	46'	10"
c	48°	08'	22"
d	42°	17'	01"
e	35°	49'	09"
f	54°	02'	58"
g	47°	51'	18"
h	31°	59'	07"
sum	360°	01'	00"
	− 360°	00'	00"
		01'	00"

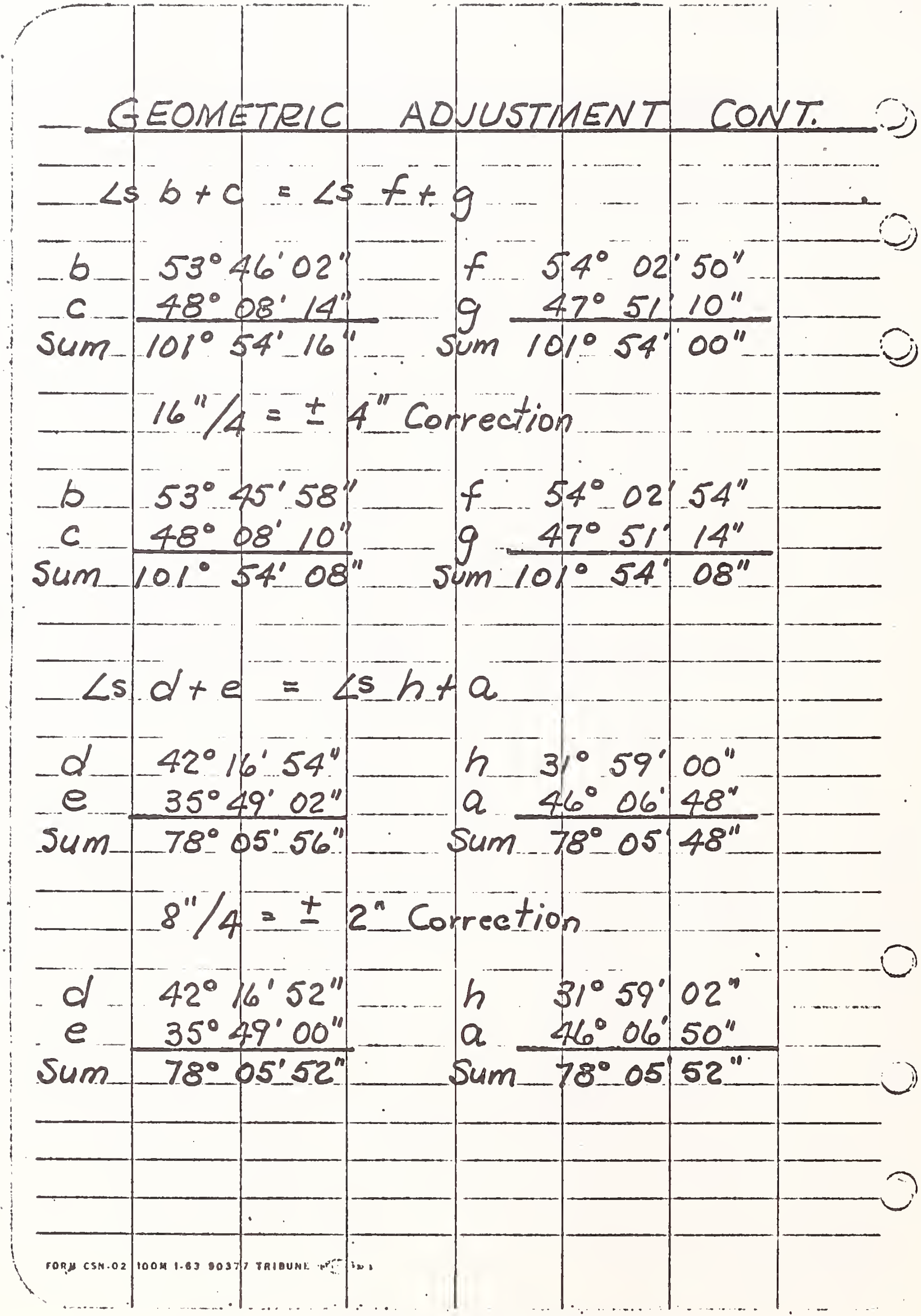
$\frac{60''}{8} = 7.5''$ Correction

Corrected.

a	46°	06'	48"
b	53°	46'	02"
c	48°	08'	14"
d	42°	16'	54"
e	35°	49'	02"
f	54°	02'	50"
g	47°	51'	10"
h	31°	59'	00"

FORM CSN-02 100M 1-63 90377 TRIBUNE

FIGURE No. 8



GEOMETRIC ADJUSTMENT CONT.

∠s b + c = ∠s f + g

b	53° 46' 02"	f	54° 02' 50"
c	48° 08' 14"	g	47° 51' 10"
Sum	101° 54' 16"	Sum	101° 54' 00"

16"/4 = ± 4" Correction

b	53° 45' 58"	f	54° 02' 54"
c	48° 08' 10"	g	47° 51' 14"
Sum	101° 54' 08"	Sum	101° 54' 08"

∠s d + e = ∠s h + a

d	42° 16' 54"	h	31° 59' 00"
e	35° 49' 02"	a	46° 06' 48"
Sum	78° 05' 56"	Sum	78° 05' 48"

8"/4 = ± 2" Correction

d	42° 16' 52"	h	31° 59' 02"
e	35° 49' 00"	a	46° 06' 50"
Sum	78° 05' 52"	Sum	78° 05' 52"

FORM CSN-02 100M 1-63 90377 TRIBUNE

FIGURE No. 9

Also the sum of the eight lettered angles in the figure must equal 360°, since they form the interior angles of a closed figure of four sides.

$$a+b+c+d+e+f+g+h = 360^{\circ} \quad (5)$$

Further since the opposite angles at the intersection of the diagonals must be equal, it follows that:

$$b+c = f+g \quad (6)$$
$$d+e = h+a \quad (7)$$

If any three of these seven equations are satisfied, the other four must of necessity be satisfied also. Equations (5), (6) and (7) are the ones most convenient to use.

1. Using the values resulting from the station adjustment, add the eight angles, a, b, c, d, e, f, g and h and subtract their sum from 360°. Divide the difference by 8, and algebraically add the result to each of the eight angles, thus satisfying the conditions of equation (5).

2. Using the adjusted values from "1", find the difference between the sums (b+c) and (f+g) and divide that difference by four. Apply the results as a correction to each of the four angles, increasing each of the two whose sum is the smaller and decreasing each of the two whose sum is the larger, thus making these angles satisfy equation (6) without disturbing the adjustment for equation (5). Proceed in the same way for each of the four angles involved in equation (7).

c. Figure Adjustment for Trigometric Condition (Figure 10)

If the length of one line, as AB, is known, and the length of the opposite side CD is to be computed, the computer may select one or another series of triangles for use in accomplishing this result. For example, a solution of triangle ABC gives the length of AC, then from triangle ACD the required length of CD is found; or in the triangle ABC the length BC is found, then in BCD the length CD is computed. There are four possible choices of route through the figure. It now remains to be seen whether the angles, as so far adjusted, are so related as to make the value of the length of a computed side independent of the route used.

TRIGONOMETRIC ADJUSTMENT

log sin	a	46° 06' 50"	9.857768	2
	c	48° 08' 10"	9.871998	2
	e	35° 49' 00"	9.767300	3
	g	47° 51' 14"	9.870075	2
sum			9.367141	
log sin	b	53° 45' 58"	9.906666	2
	d	42° 16' 52"	9.827862	2
	f	54° 02' 54"	9.908221	2
	h	31° 59' 02"	9.724017	3
sum			9.366766	
				18

$$\begin{array}{r} 9.367141 \\ -\ 9.366766 \\ \hline 375 \end{array}$$

$375/8 = 47 = X$ $\qquad$ $18/8 = 2.25 = Y$

$\frac{X}{Y} = \frac{47}{2.25} = 21''$ Correction

Final ∠s to be used for Computations

a	46° 06' 29"	b	53° 46' 19"
c	48° 07' 49"	d	42° 17' 13"
e	35° 48' 39"	f	54° 03' 15"
g	47° 50' 53"	h	31° 59' 23"

FIGURE NO. 10

Assume that the length of AB is known and the length of CD is to be found.

$$AD = AB \frac{\sin c}{\sin h}$$

$$CD = AD \frac{\sin a}{\sin f} = AB \frac{\sin a \quad \sin c}{\sin f \quad \sin h} \qquad (8)$$

Similarly,

$$CD = AB \frac{\sin b \quad \sin d}{\sin e \quad \sin g} \qquad (9)$$

Equating these two values of CD,

$$\frac{\sin a \quad \sin c}{\sin f \quad \sin h} = \frac{\sin b \quad \sin d}{\sin e \quad \sin g} \qquad (10)$$

Or

$$\frac{\sin a \quad \sin c \quad \sin e \quad \sin g}{\sin b \quad \sin d \quad \sin f \quad \sin h} = 1 \qquad (11)$$

Expressed in logarithims form, this is

$$(\log \sin a + \log \sin c + \log \sin e + \log \sin g)$$

$$- (\log \sin b + \log \sin d + \log \sin f + \log \sin h) \qquad (12)$$

The angles are tested for satisfaction of this equation by adding the logarithmic sines in the two groups as indicated and by finding the difference between the two sums.

A simple approximate method of adjustment which gives an equal correction to each angle and does not disturb the geometric condition is as follows: (See adjustment in the example as shown)

a. Record the log sines as shown in the example.

b. For each angle, record the tabular logarithmic sine difference for 1" opposite each logarithm.

c. Find the average required change (x) in log sine by dividing the difference between the sums by 8.

d. Find the average difference (y) for 1".

e. The ratio x/y gives the number of seconds of arc to be applied as a correction to each angle.

f. Add this correction to each of the four angles the sum of whose log sines is the smaller, and subtract it from each of the angles the sum of whose log sines is the larger, and thus the corrected values are obtained.

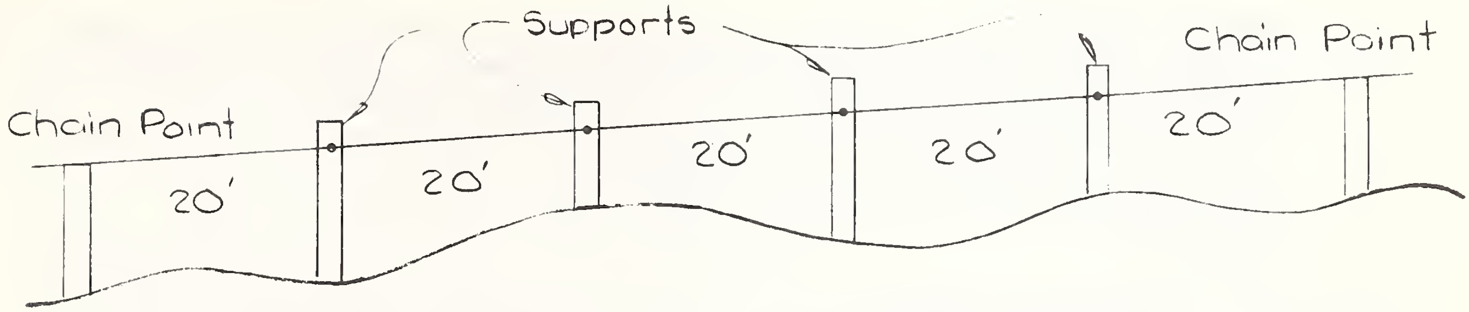
8. If the computed length of the check base line compares to the measured length within the prescribed limits of error, proceed with the layout of the substructure units. This preferably should be done from the two points previously set on the centerline, in accordance with the procedures for direct chaining. Referencing of substructure units and checking of span lengths should be accomplished as described previously to the greatest extent possible. If direct chaining is not permissible, location of substructure units can be accomplished by triangulation as shown on Drawing No. 5. Angles are calculated and turned from each base line for each point required. Angles used for this purpose must be greater than 6°. The functions of angles of less than 6°, in tables generally used for calculation, are not sufficiently accurate to permit calculation of the angle to the required precision. It is extremely important to reference triangulation points to permit accurate re-establishment at any time.

35.07 General Information - Horizontal Control

1. Chaining - The following are the effects various factors have on chaining:

Factor	(The Deviations Below Will Cause an Error of 0.01 per Chain Length)	(Makes Chain)
Temperature	15° F.	Long or Short
Tension	15 Lb. (1½ lb. chain)	Long or Short
Slope	1.4 Ft.	Short
Horizontal Line	1.4 Ft.	Short
Wind	0.6 Ft. Bow in Center	Short
Plumbing (Breaking Chain on Steep Slope)	0.5' to 0.10' per 100' Chain Length	Long or Short

SLOPE CHAINING



1. Standardize chain for the condition shown.
2. Set stakes on line with transit.
3. Record elevations on top of stakes at ends of chain interval.
4. Place nails for chain support in intermediate stakes on straight line grade between end stakes.
5. Fasten securely to top of end stakes a strip of copper, lead, aluminum or other soft metal that can be scribed.
6. Pull chain to proper tension. Rear chain on scribe mark. Head chain scribes mark.
7. Record temperature

RELATIONSHIP OF ANGULAR TO LINEAR ERROR

ANGULAR ERROR	LINEAR ERROR in 1,000 Ft.	RATIO OF ACCURACY
0° 10' 00"	2.9089	1/344
0° 05' 00"	1.4544	1/688
0° 01' 00"	0.2909	1/3,440
0° 00' 30"	0.1454	1/6,880
0° 00' 20"	0.0970	1/10,300
0° 00' 10"	0.0485	1/20,600
0° 00' 05"	0.0242	1/41,200
0° 00' 01"	0.00484	1/206,600

FIGURE No. 11

2. Measurement by chaining slope distance, measuring vertical angle, and computing horizontal distance. The accuracy of this method is limited to the accuracy to which the vertical angle can be determined in addition to the above factors. In the case of a transit with a one minute vernier on the vertical circle, the following is an example:

Vertical Angle	Probable Limits of Error in Ft. per 100 Ft.
20°	+ 0.01 to - 0.01'
30°	+ 0.01 to - 0.01'
45°	+ 0.02 to - 0.02'

It is important that correction be made for the index error of the instrument when measuring the vertical angle.

3. Setting of Points. The following factors should be considered in choosing materials and methods for survey points.

    a. Length of expected need. Do not expend a lot of effort in setting points required for a short time. Points to be retained for long periods such as triangulation stations and primary control references will justify the expenditure of extra effort as replacement is costly.

    b. Stakes. These can include the usual 2" x 2" hubs, iron pins, 2" x 4" stakes, etc. Iron pins and 2" x 4" stakes should be a minimum of 18" long. In general drive them flush with the ground. Soil conditions, both present and expected future, will normally determine the type of stakes. If unusual conditions are encountered, acquisition of materials other than what is normally supplied is justified as each point represents a considerable investment in time and money.

    c. Guard Stakes. Clearly identified the point on the guard stakes and replace as required. It is suggested for further protection in addition to the guard stakes, a 2" x 4" x 4' or 4' steel bar with a large cloth flag be driven securely in place to protect the primary control points. DO NOT USE FLAG NEAR RAILROAD OR IMMEDIATELY ADJACENT TO P.T.W. Check with railroad authorities before placing any stakes, lath, etc. on railroad right of way. Any type of flag is generally unacceptable to them.

d. Iron pins are generally used for bench marks. Leave top approximately 1" above ground. In some cases, it may be necessary to place concrete around pin to prevent settlement or displacement.

35.08 Vertical Control - Bench Marks

Plan locations of bench marks to permit control of the work with the least amount of turns. Locate bench marks in areas where they will not be disturbed or subject to settlement and are readily accessible.

1. Locate in the field at least three of the bench marks shown on the plans.

2. Establish points for bench marks needed in the vicinity of the structure. A minimum of two are required. Do not locate bench marks on newly placed fills; in areas subject to movement from frost action, slides, etc. or on superstructures of existing bridges. Also avoid areas near edges of fill as these are subject to displacement from weight of fill.

3. Check adjustment of level.

4. Beginning at a bench mark shown on the plans, run levels through the bench marks set for the structure to a second and third bench mark shown on the plans and close the circuit back to the point of beginning. Attempt to balance backsight and foresight distances. Turn through each and every bench mark. Bench mark elevations set by side shots are of no value and have no place in bridge construction surveys. Use reciprocal leveling procedures for long river crossings or other situations where length of foresight exceeds 300'.

35.09 Vertical Control - Construction Grades

1. General. It is good practice to utilize at least two bench marks in setting or checking construction grades. This will detect possible settlement of bench marks as well as calculation and observation errors.

2. The following are the limits of permissible error for various units of structure: (Listed on following page)

Point or Portion of Structure	Limit of Permissible Error
Bench Mark	±0.05' $\sqrt{\text{Distance in Miles}}$
Footing X-Section	±0.05' of Plan Elevation-Nearest 0.1'
Footing Cut Stake	±0.02' of Plan Elevation-Nearest 1/4"
Footing Elevation	±0.02' of Plan Elevation-Nearest 1/4"
Column Elevation	±0.02' of Plan Elevation-Nearest 1/4"
Top of X-Beam	±0.01' of Plan Elevation-Nearest 1/8"
Beam Seat, Structural Steel Splices, Curbs, Deck Slab Forms	±0.01' of Plan Elevation-Nearest 1/8"
Beam 10th Point, Top of Deck, Guard Angle, Expansion Joints	±0.005' of Plan Elevation-Nearest 1/16"

3. Structure Excavation Cross-Sections. Take sufficient number of shots to permit quantity calculations to be made. Precision required for shots - nearest 0.10'.

4. Set stakes showing cut to bottom footing. Rod read to nearest 0.01' and cut shown to 0.01'. Indicate on stake from where cut is to be measured.

5. Check to see grades for footing and column forms have been set to within 1/4" of plan elevation.

6. Grades for tops of crossbeams and beam seat should be within 1/8" of plan elevation.

7. A rod level should be used in cases where it is necessary to use a high rod and where waving the rod is not possible or practical.

8. Turning points should be chosen or set that will not settle between foresight and backsight.

9. In checking and setting grades for construction, it is very desirable to take check shots on points of known elevation of other units of structure already completed.

35.10 Fill Settlement Check Elevations

Whenever the sequence of work calls for a specific settlement period to elapse after the roadway embankment is completed, there is no guarantee that the settlement will occur or be completed by the end of the specified time. It merely allows the fill a period of time in which the major part of the expected settlement or consolidation can occur. The following steps should be taken whenever settlement elevations are being established and shall start immediately upon completion of the fill at the bridge end. (See Figure No. 12 for typical installation).

1. Establish enough points so that if several are destroyed, sufficient points are left to complete the record.

2. Set some of the points in positions where they are not likely to be destroyed by necessary operations.

3. Tie levels between two established bench marks; do not depend on one as it can be affected by settlement of nearby fill.

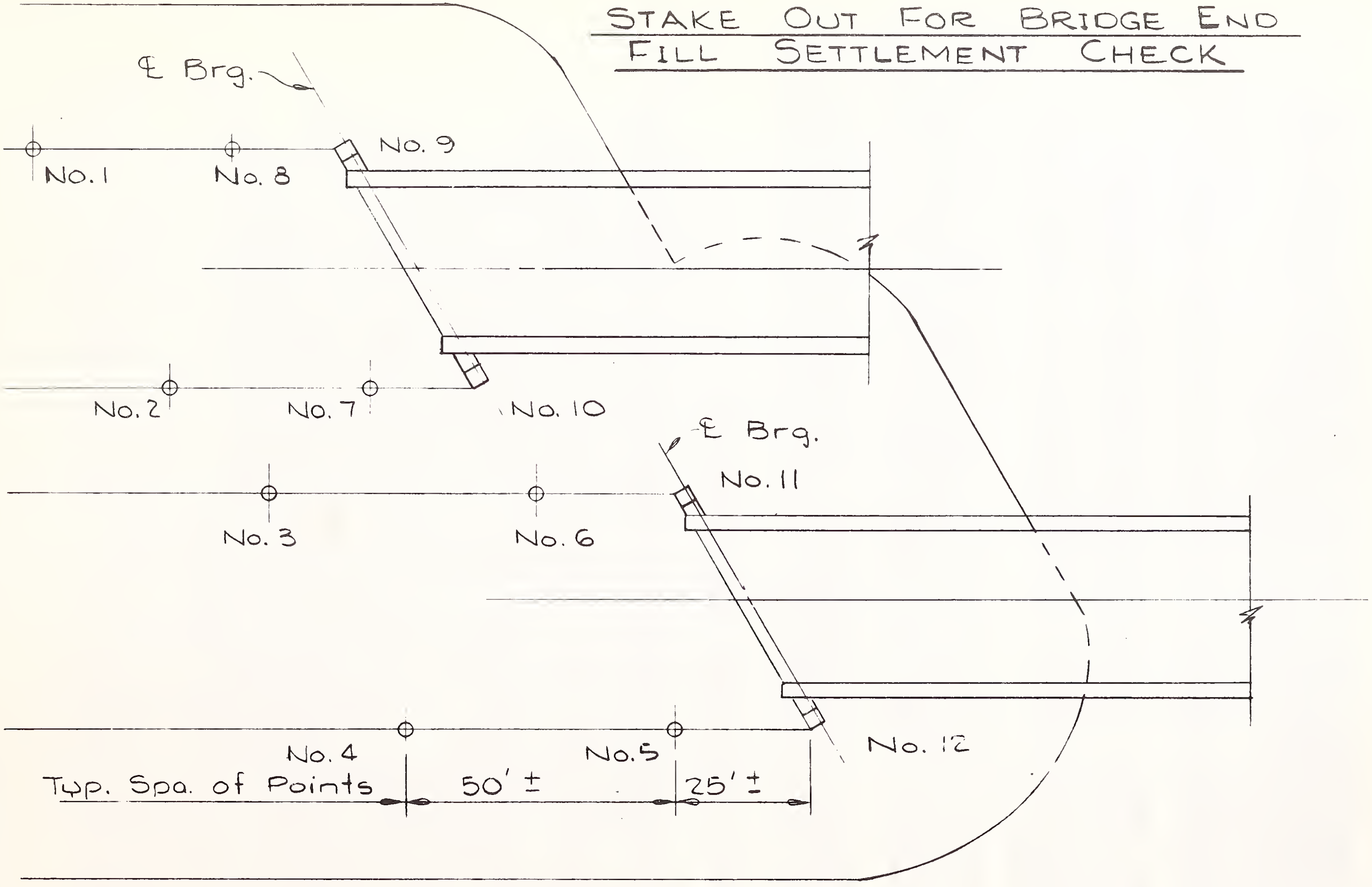
4. Take and record readings at least once a week. When three or four weeks pass with no movement noted, this may be reduced to once every second week. Submit copies of all readings to the Construction Bureau.

With an accurate record available for review, it may be possible that a portion of the stipulated fill settlement period may be waived. If settlement is still occurring at the end of the specified period, full details should be submitted for review.

35.11 Structure Settlement Check Elevations

Whenever structure settlement is noted on completed items of work, the Construction Bureau should be notified immediately and a settlement record system started. This will be done by establishing permanent marks on or over the substructure units by marking an X on the guard angles, floor joints or concrete near the face of both curbs and on centerline at each and every bent or pier. Take and record readings at least once a week until three or four weeks pass with no movement noted. Then continue readings every second week until you are satisfied settlement has ended. Submit copies of field records to the Construction Bureau. You will be advised as to the corrective action to be taken. Place bench marks on the ends of all newly placed caps of bents and piers and record the elvations to the nearest 0.01'. This must be done as soon after the concrete is placed as practical. This will provide information as to whether differences in elevations that may be noted later are due to settlement or are due to a possible error in elevation during construction. If the difference in elevation is actually due to settlement, it is important to know if it took place rapidly or slowly and if it is still occurring.

STAKE OUT FOR BRIDGE END FILL SETTLEMENT CHECK



Note: Establish and use Bench Marks which are sufficient distance from the fill area so that their accuracy will not be affected by any settlement or consolidation which takes place under the fill.

FIGURE No. 12

35.12 Structures Involving Railroads

1. On railroad grade separation work, the stationing of the mainline tracks or other railroad reference line shown on the plans should be carefully checked to assure that proper lateral clearances will be provided.

2. The first step in locating a structure over a railroad is to establish the point where the centerline of roadway or centerline of structure intersects with the centerline of the Mainline Tracks. The rest of the structure will be layed out from this point disregarding any discrepancy in roadway stationing of structure units.

3. Take elevation on top of rail at sufficient locations in vicinity of structure to assure proper vertical clearance is provided. This information is also helpful for shoring and cribbing plans and in case a question arises over the effect construction activities are having on the tracks.

4. The following are some precautions to be observed in stake-out near or on railroads:

    a. Watch for trains.

    b. Do not allow steel chain to drop across tracks. This will lead to an unpleasant visit from railroad officials in a very short while.

    c. Do not allow chain or other equipment to come in contact with trolley wires, high tension wires, etc. This will lead to the need for a NEW SURVEY CREW.

35.13 Management of Engineering Control Surveys

Good management practices are equal in importance to good engineering practices in reducing costly engineering control errors in bridge construction.

A. General

Layout and engineering control of bridges requires precision not necessary nor generally practiced on most other highway construction. This is due mainly to the materials used in the construction of bridges. Once concrete is in the forms and hardened, correction of any mistakes is very costly and time consuming. Errors in span lengths, column lengths, cap elevations, etc. generally require costly modifications to be made. Very probably Federal participation in these modifications will be limited or non-existent. For the reasons given, it is necessary that every effort be made to provide this precision.

B. Assignment of Personnel

IT IS DESIRABLE TO ASSIGN THE SAME PERSONNEL TO STAKING WORK WHO WILL BE ENGAGED IN THE ENGINEERING CONTROL AND INSPECTION OF CONSTRUCTION FOR THE PROJECT. It is generally accepted that more interest is shown and more care is taken in survey work when a person knows that he is going to be responsible for construction of the facility for which the survey is being made. Work of new or temporary personnel or permanent personnel new to bridge work should be carefully observed. Any personnel who cannot or will not work with accuracy required cannot be tolerated on bridge work due to high costs of correcting structure errors.

C. Time Allowed for Staking

It is imperative to allow sufficient time for checking plans, staking, referencing, and checking of primary controls for the structure prior to the beginning of construction work. Consideration must be given to expected weather conditions, availability of points, terrain, required accuracy of survey, etc.

On multiple structure projects, it is desirable to allow time sufficient for establishing primary controls for all structures as this permits establishing of construction controls with a minimum of time and effort and frees personnel for inspection duties during construction. The practice of delaying establishment of controls to the last minute or of the project personnel arriving on the project at the time the contractor is ready to begin work leads to a choice between two unacceptable alternatives:

1. Suspend contractor's operations until staking, checking and referencing are complete. The Federal Highway Administration does not recognize this as a legitimate reason for suspension of work and will assess the State liquidated damages if contract time overruns.

2. Provide only minimal staking without proper referencing and staking to allow work to begin. Too often the second alternative results in very costly errors. Proper management and planning can eliminate the need for making this choice.

D. Equipment

Equipment capable of producing the required accuracy must be made available and used. The precision required for bridge construction survey controls justifies the use of more sophisticated equipment than is normally used on highway work.

Layout of engineering controls is generally a major expense in construction engineering costs. The use of equipment that will provide the necessary accuracy with less time expended can help reduce these costs. For primary control system staking for a structure, it is highly desirable that a theodolite be made available. For long span steel structures or situations involving triangulation from base lines where permissible error is less than 1 in 10,000, its use is practically mandatory. The following is a list of major survey equipment necessary for structure layout.

1. Project

Minimum - Transit in excellent condition; chain - checked against standard and standardized for all expected conditions of use; level - automatic, in good condition.

2. Division Office

Standard chain for comparision and standardizing of chains in the field. Upon request, arrangements can be made with the Montana State University Civil Engineering Department to compare a new chain against a standardized Lovar chain. One such new chain per Division should be available for comparison with chains used in the field.

E. Project Management of Engineering Control

1. Review and check plans prior to beginning staking. Do not grab plans, head for a structure and begin staking as soon as you come on a project just to keep everyone busy. This can and very often does lead to costly errors and aggravating duplication of work. All personnel should at least have an opportunity to review plans and become familiar with construction details affecting layout.

2. Plan layout and referencing to keep duplication of work to a minimum. The time spent on planning, prior to layout, will save valuable time during construction. For instance - it is not reasonable to make layout of footing centerlines, etc. in areas where channel excavation must be removed prior to bridge work.

3. Make contractor, and particularly the superintendent, aware of their specified responsibility in the preservation of control points. Advise of the possible cost and time necessary for replacement. Also advise that should it become necessary to remove or disturb a point to allow construction operations, prior notification is required. This should be discussed at the Pre-construction Conference.

   Prior to staking of controls in the immediate construction areas, consult with contractor's personnel in charge of work to determine convenient locations not subject to disturbance for the period they are required. Make it understood that these are being placed for his use with the intention that it will be done one time only.

   In cases where continual careless, or willful destruction of control points occurs, action should be taken to prevent expensive, time consuming replacement. It is not unreasonable to expect that sufficient care be taken so as not to disturb a small area around a 2" x 2" hub. Actions that can be considered and are allowable under the Specifications include deduction of the expense of replacement from the contractor's estimate and the removal of uncooperative contractor personnel from the project.

4. It is desirable that the contractor furnish a proposed schedule of operations and keep it current to allow determination of manpower and equipment needs for timely staking.

5. Notice should be given by the contractor for checking of forms, etc. sufficiently in advance to permit timely checking and efficient utilization of project personnel. Procedures for this should be established at the beginning of construction.

F. Impress on project personnel the need for constant checking of the work. Make every effort to keep them aware of this need throughout the time of construction. Rough checks that take very little time or effort, visual comparison of column heights to approach fills and other bents, taping between like units on separate bents, can and have disclosed gross errors in design or layout and prevented costly extra work. The elimination of errors is mainly dependent on constant checking.

CHAPTER IV
CONSTRUCTION DETAILS

CONSTRUCTION MANUAL

CHAPTER IV

CONSTRUCTION DETAILS

IV-40 CLEARANCE OF RIGHT-OF-WAY

40.00 References
40.01 General
40.02 Protection and Preservation of Property
40.03 Clearing and Grubbing
40.04 Removal of Buildings, Structures and Obstructions
40.05 Disposal of Removed Material
40.06 Hazards
40.07 Records and Documentation

IV-41 EXCAVATION AND EMBANKMENT

41.00 References
41.01 General
41.02 Preparation of Roadway Foundation
  A. Removing Topsoil
  B. Cut to Fill Transitions
  C. Embankment Foundation
  D. Subgrades in Cut Sections
41.03 Excavation
  A. Prewetting Excavation Areas
  B. Unsuitable Materials
  C. Excess Material
  D. Slopes
  E. Types of Excavation
    1. Unclassified Excavation
    2. Borrow Excavation
    3. Channel Excavation
    4. Street Excavation
41.04 Blasting of Rock Cuts
  A. Presplitting
  B. Blasting Record Form CSN 55
41.05 Embankments
  A. Rock Embankment
  B. Earth Embankment
  C. Embankment Over Swampy Areas
  D. Embankment at Structures
  E. Compaction, Moisture and Density
41.06 Finishing and Cleanup
41.07 Maintenance of the Roadbed
41.08 Records and Documentation

IV-42 OVERHAUL

42.00 References
42.01 General
42.02 Mass Diagram
42.03 Haul
42.04 Records

CONSTRUCTION MANUAL

CHAPTER IV

CONSTRUCTION DETAILS

IV-43 WATERING

- 43.00 References
- 43.01 General
- 43.02 Inspection
- 43.03 Records

IV-44 ROADSIDE DEVELOPMENT

- 44.00 References
- 44.01 General
- 44.02 Topsoil
- 44.03 Conditioning Seedbed Surface
- 44.04 Seeding
- 44.05 Fertilizer and Mulch
- 44.06 Planting
- 44.07 Planting Inspection
  - A. Storage
  - B. Handling and Planting Bare Root Stock
  - C. Handling and Planting Canned or Balled and Burlap Stock
  - D. Pruning
  - E. Inspection at Time of Planting
- 44.08 Establishment Periods
- 44.09 Records
  - A. Seeding Notes
  - B. Planting Notes

IV-45 AGGREGATE PRODUCTION AND SURFACING

- 45.00 References
- 45.01 General
- 45.02 Crushing and Screening
- 45.03 Stockpiling
- 45.04 Scales
  - A. Belt Scales
  - B. Scale Inspection
- 45.05 Spreading and Compaction
- 45.06 Automatic Grade Control
- 45.07 Maintenance of Completed Base Surface
- 45.08 Records
- 45.09 Scalemans Duties

IV-46 CEMENT TREATED BASE

- 46.00 References
- 46.01 General
- 46.02 Roadbed Preparation

CONSTRUCTION MANUAL

CHAPTER IV

CONSTRUCTION DETAILS

IV-46 CEMENT TREATED BASE (con't)

46.03 Mixing
46.04 Placing and Finishing
46.05 Inspection and Records

IV-47 ASPHALT CONCRETE PAVEMENT

47.00 References
47.01 General
47.02 Roadbed Preparation
47.03 Mix Design
47.04 Plant and Inspection
  A. General
  B. Cold Feed
  C. Dryer
  D. Dust Collector
  E. Screening Unit
  F. Hot Aggregate Bins and Gate
  G. Scales (Batch Plant)
  H. Asphalt Storage Tanks
  I. Pugmill Mixer
  J. Scales
  K. Mix Proportioning
  L. Plant Inspectors Check List
  M. Daily Plant Mix Report
47.05 Paving Operation and Inspection
  A. General
  B. Traffic Control
  C. Equipment Inspection
  D. Hauling Plant Mix
  E. Spreading
  F. Compacting the Mix
  G. Joints and Surface Smoothness
  H. Paving Inspectors Checklist

IV-49 ROAD MIXED ASPHALT SURFACING

49.00 References
49.01 General
49.02 Roadbed Preparation
49.03 Equipment Inspection
49.04 Mixing
49.05 Spreading and Compacting
49.06 Records

CONSTRUCTION MANUAL

CHAPTER IV

CONSTRUCTION DETAILS

IV-50 SEAL COAT

50.00 References
50.01 General
50.02 Material
  A. Bituminous Material
  B. Cover Material
50.03 Roadway Surface Preparation
50.04 Equipment
  A. Bituminous Equipment
  B. Aggregate Equipment
    1. Spreaders
    2. Rollers
50.05 Application
  A. Bituminous Material
  B. Cover Material
50.06 Traffic Control
50.07 Records

IV-51 PORTLAND CEMENT CONCRETE PAVEMENT

51.00 References
51.01 General
51.02 Preparation Before Placing Concrete
  A. Forms-Form Setting and Alignment
  B. Equipment-Inspection
51.03 Concrete Production
  A. Material Inspection
  B. Plant Inspection
  C. Mixing Methods
  D. Mixing Limitations
51.04 Placing and Finishing
51.05 Surface Test
51.06 Curing
51.07 Removing Forms
51.08 Slip Formed Concrete Pavement
51.09 Bump Cutting Hardened Concrete Pavements
51.10 Protecting the New Pavement
51.11 Opening to Traffic
51.12 Tolerances in Pavement Thickness
51.13 Inspection Reports, Records and Diary

IV-52 REINFORCING STEEL

52.00 References
52.01 General
52.02 Material and Inspection
52.03 Records and Documentation

CONSTRUCTION MANUAL

CHAPTER IV

CONSTRUCTION DETAILS

IV-55 EXCAVATION FOR CULVERTS AND MINOR STRUCTURES

- 55.00 References
- 55.01 General
- 55.02 Inspection
- 55.03 Traffic Control
- 55.04 Excavation
  - A. Swamp
  - B. Rock
  - C. Silt and Fine Sand
  - D. Chemical in Soil
- 55.05 Grade Stakes and Hubs
- 55.06 Compaction
- 55.07 Measurement Culvert Excavation and Bedding Material
  - A. Culvert Excavation
  - B. Bedding Material

IV-56 GENERAL INFORMATION ON INSPECTION AND INSTALLATION OF CULVERTS

- 56.00 References
- 56.01 General
- 56.02 Revised Culvert List
- 56.03 Staking Inspection
  - A. Flowline
  - B. Slope
  - C. Length
- 56.04 Backfilling and Compaction
- 56.05 Sewers
- 56.06 Records and Documentation

IV-57 INSPECTION AND INSTALLATION OF CORRUGATED METAL PIPE

- 57.00 References
- 57.01 General
- 57.02 Materials Inspection
- 57.03 Assembly and Installation
  - A. General
  - B. Drain Pipe
  - C. Irrigation Pipe
  - D. Syphon Pipe
- 57.04 Records and Documentation

CONSTRUCTION MANUAL

CHAPTER IV

CONSTRUCTION DETAILS

IV-58 INSPECTION AND INSTALLATION OF REINFORCED CONCRETE PIPE

- 58.00 References
- 58.01 Materials Inspection
- 58.02 Assembly and Installation
  - A. General
  - B. Irrigation and Syphon Pipe
  - C. Drain Pipe
- 58.03 Records and Documentation

IV-59 INSPECTION AND INSTALLATION OF STRUCTURAL PLATE PIPE CULVERTS AND STOCKPASSES

- 59.00 References
- 59.01 General
- 59.02 Assembly and Installation
- 59.03 Backfilling and Compaction
- 59.04 Records and Documentation

IV-60 INSPECTION AND INSTALLATION OF PIPE UNDERDRAINS

- 60.00 References
- 60.01 General
- 60.02 Material Inspection
- 60.03 Assembly and Installation
- 60.04 Backfilling and Compaction
- 60.05 Measurement
- 60.06 Records and Documentation

IV-61 REMOVE AND RELAY CULVERTS

- 61.00 References
- 61.01 General
- 61.02 Assembly and Installation
- 61.03 Backfilling and Compaction
- 61.04 Measurement
- 61.05 Records and Documentation

IV-62 MISCELLANEOUS RIGID PIPE

- 62.00 References
- 62.01 General
- 62.02 Non-Reinforced Concrete Pipe
- 62.03 Clay Pipe
- 62.04 Cast Iron Pipe
- 62.05 Asbestos Cement Pipe
- 62.06 Fiber Pipe
- 62.07 Plastic Pipe

CONSTRUCTION MANUAL

CHAPTER IV

CONSTRUCTION DETAILS

IV-63 CURBS AND GUTTERS

- 63.00 References
- 63.01 General
- 63.02 Materials
- 63.03 Construction
  - A. Concrete Curbs
    - 1. Foundation and Preparation of Forms
    - 2. Placing Concrete
    - 3. Finishing Concrete
    - 4. Joints
    - 5. Curing
    - 6. Testing
  - B. Asphalt Curbs
- 63.04 Records

IV-64 FENCE

- 64.00 References
- 64.01 General
- 64.02 Materials
- 64.03 Construction
  - A. Layout-All Fence Types
  - B. Post Holes, Backfilling and Setting Posts
  - C. Panels
  - D. Installing Wire
- 64.04 Contractor Co-operation, Contract Time and Insurance on Fencing Contracts
- 64.05 Inspection and Records

IV-69 MARKERS AND MONUMENTS

- 69.00 References
- 69.01 General
- 69.02 Materials
- 69.03 Construction
- 69.04 Records

IV-70 TRAFFIC CONTROL

- 70.00 References
- 70.01 General
- 70.02 Planning
- 70.03 Guidelines for Design & Operation
- 70.04 Elements of a Trafficway
- 70.05 Flagmen
- 70.06 Informing the Public
- 70.07 Keep It Clear and Clean
- 70.08 Speed Zones
- 70.09 Payment

CONSTRUCTION MANUAL

CHAPTER IV

CONSTRUCTION DETAILS

IV-74 PNEUMATICALLY APPLIED MORTAR

74.00 Reference
74.01 General
74.02 Materials
74.03 Construction
  A. Equipment
  B. Preparation of Surface to Receive Mortar
  C. Applying Mortar
  D. Forms
  E. Reinforcement
  F. Alignment
  G. Rebound
74.04 Finishing and Curing
74.05 Inspection and Testing

IV-75 TEMPORARY EROSION AND SEDIMENTATION CONTROL

75.00 References
75.01 General
75.02 Surface Protection of Exposed Soils
  A. Mulches
  B. Mats and Mesh Covers
  C. Sodding
75.03 Control of Runoff Water
  A. Runoff Diversion
  B. Slope Drains
75.04 Trapping of Sediments
75.05 Records and Documentation

Appendix 75-A Utah Department of Highways, Report on Burlap Embankment Protectors

Appendix 75-B Erosion Control Practice

Appendix 75-C Sample, Temporary Erosion Control Plan

IV-40 CLEARANCE OF RIGHT-OF-WAY

40.00 References

Standard Specifications: Section 10

Construction Manual: Chapter III

40.01 General

The right-of-way and any designated easements must be prepared as the initial operation of constructing a highway facility. Preparation will include, removal of obstructions and objectionable materials, and their disposal in accordance with the governing specifications and special provisions. Items to be removed include trees, undergrowth, stumps, rubbish, buildings, foundations, abandoned utilities, drainage structures and any other material or objects not needed in the construction.

Boundaries of all work areas and clearing limits must be distinctly marked and these limits clearly explained to the contractor. The contractor should be alerted as to what access routes have been provided or are available for his use. The contractor should also be reminded of limitations on the amount of erodible area that may be exposed by clearing and grubbing operations without providing erosion control.

The engineer and the contractor should choose a time prior to construction to travel over the job and discuss the general work to be done and any special details. Some of the details to be discussed could include the trees to be saved, stakes and survey points to be preserved, and all known utilities that could be damaged during the clearing operations. The general clearing procedure and schedules, as well as the burning or disposal schedules should also be discussed and the proper notation made in the project diary.

The method of measurement and payment for clearing and grubbing is to be discussed and clearly explained to the contractor or his representative prior to the performance of the work. Any misunderstandings or misinterpretations of the method of measurement or payment must be clarified at this time. The Division Construction Supervisor or Construction Bureau Chief should be contacted immediately if misunderstandings involving the method of measurement or payment occur between the Project Manager and the contractor. The Division Construction Supervisor should also be informed as soon as possible of any changes in the planned quantities that are necessary to complete the clearing and grubbing work.

If the project, or portions of it, are in the National or State Forest, or National Park boundary, representatives of those organizations should be contacted by the Project Manager before construction operations begin to determine if regulations other than those set forth by the Department of Highways will apply to those areas.

40.02 Protection and Preservation of Property

The contractor is responsible for the protection and preservation of all property in and adjacent to the highway right-of-way. Existing highway improvement, utility facilities, adjacent buildings, fences, trees and shrubbery may require protection. The Project Manager should notify the contractor of what features need protection and mark these features clearly so they will not be destroyed. Many methods may be used to protect various properties. The contractor may erect protective fences, construct dikes, or place timbers around existing trees and shrubs for his convenience. The cost of any protective measure, unless that measure is a contract pay item or quantity, is borne by the contractor. The engineer should not direct the contractor in methods or equipment to be employed in preserving or protecting property, but must only assure that the correct goal will result. If the wrong methods are being used it is the responsibility of the Project Manager to alert the contractor to the probable outcome, but it is the contractors prerogative to change. If methods used are to the detriment of completed work or will endanger life or property, the Project Manager must call an immediate halt to the work.

Property may become damaged in spite of protective measures taken, yet the contractor must replace, restore, or satisfactorily adjust any property that has been damaged by his operations.

A careful investigation is to be made to determine the location and depth of all underground facilities within the right-of-way. Occasionally, utilities are in place at the time the contract is awarded, which have not been detailed on the plans or on various right-of-way agreements. The contractor must be kept informed of the intended time of removal or relocation of these facilities and this will require coordination between the utility company engineer and the contractor.

Objects of historical or archeological value that are to be preserved or remain in place must be clearly marked and the contractor informed of their location.

40.03 Clearing and Grubbing

The choice of equipment to be used in the clearing and grubbing operation is left to the contractor as long as that equipment will perform the work in a satisfactory manner. Limitations in the choice of equipment or method do exist depending on proximity of adjacent buildings or facilities. Common sense should dictate the method employed when using explosives in congested areas and the choice of the equipment to perform clearing and grubbing in restricted areas.

Trees and shrubs, which will not interfere with the use of the highway and its drainage system are often selected to remain in place for their scenic or historic value. Dead, dying or otherwise unstable trees, which are within the right-of-way limits, but could fall onto the completed roadway should be removed. Large trees at the top of cut slopes which could be uprooted by wind should be removed. Branches of trees extending over the roadbed should be trimmed to give a clear height of approximately 20 feet above the roadbed surface. Trimming should be done by skilled workmen and be in accordance with good tree surgery practice.

Tree stumps or large roots should be removed from the excavation or embankment areas to a depth that will satisfy specifications and prevent objectionable material from being mixed with the embankment soil. Areas of heavy timber, closely spaced small trees and undergrowth may require root raking to remove the majority of roots left in the ground after clearing. The Standard Specifications allow the engineer to authorize stumps to remain in place, providing they do not extend more than six inches above the ground line or low water level, or will be covered by a minimum of 4 feet of subgrade or slope embankment. This specification assumes that the stumps are sparsely scattered and will not be detrimental to the completed roadbed, but if doubt exists, remove them. Obviously, stumps left from heavy willow growths or similar small brush could meet the specifications and yet be completely objectionable when left under low fills. Use common sense and require removal of any stumps that may appear objectionable.

The Standard Specifications provide for clearing and/or grubbing to be within and to the staked construction limits with a tolerance not to exceed 5 feet outside these limits. The engineer should set the clearing limits at a minimum distance from centerline to provide sufficient latitude, to construct the roadway and allow proper driver safety when the roadway is completed. Clearing from right-of-way line to right-of-way line may be necessary in some instances to allow sufficient width for roadbed construction. A cleared swath from right-of-way line to right-of-way line is more costly, presents a less pleasing appearance, and allows for more erosion than when clearing is done only as needed. Care should be taken when dragging, piling or burning debris to protect the surrounding vegetation that is to remain undisturbed.

The two operations of clearing and grubbing may be set up in the contract as separate items, or as one item. The two operations of clearing or grubbing may or may not be distinct items, but the work of clearing is generally differentiated from grubbing depending upon the amount of timber on the right of way. Clearing generally involves the removal of above surface objects, whereas grubbing generally involves the removal of sub-surface roots, stumps, or other debris. However, there is no clear cut distinction between these two items only the intention of their inclusion in the contract is clear, i.e., "Objectionable materials which are or may become detrimental to the completed roadbed must be removed".

40.04 Removal of Buildings, Structures and Obstructions

The contract provisions, right-of-way agreements and special provisions concerning the removal of buildings, fences, structures, culverts, etc. should be thoroughly studied by the Project Manager and inspectors in charge or removal operations. The removal work is to be discussed with the contractors representatives concerning special details for salvage, storage, or disposal of the removable materials.

The owners of buildings, in the way of construction operation that are designated for removal, should be contacted and this work expedited as rapidly as possible.

Structures and obstructions designated for removal are to be marked or outlined by the inspector to clearly define what is to be removed and what is to remain. All designated salvage material should be removed without damage. Steel structures that are removed and are required to be salvaged should have the matching component clearly marked prior to disassembly so that reassembly at some future date is correct. Salvagable material may be stored by the contractor at specified locations within the project limits, prior to its transportation from the project. A list of the salvagable material, its location and condition, is to be made for the project files and' submitted to the Division Construction Supervisor. Arrangement can then be made for the proper disposal or re-use of the salvaged material.

Wells, frequently encountered in the route of the proposed highway, must be abandoned. Wells that will be abandoned should be permanently sealed, usually done by the owner of the well before construction. However, when such wells have not been sealed, it will be the State's responsibility to perform this work. The sealing work is done to prevent the abandoned well from acting as a channel, contaminating the underground water supply or as a water source that might saturate the roadbed.

40.05 Disposal of Removed Material

In general, the disposal site should be so selected and cared for that finished disposal sites will not detract from the aesthetics nor the environment of the adjacent area. Unsightly or otherwise detrimental disposal areas will not be approved. Disposal sites above the grade in mountainous terrain should be thoroughly inspected to prevent the possibility of the materials sliding into the roadway, which would cause unnecessary future maintenance.

Contractors may attempt to bury timber within the right-of-way to avoid the labor and equipment costs of otherwise properly disposing of cleared debris. This practice should not be permitted unless such disposal method is specified in the contract and conforms to standard specifications, and, unless the disposal area has been approved. The continual observation of the contractor's operation and examination of ravine bottoms can prevent this unacceptable practice.

Roots, stumps, tree limbs, and other slash from a clearing and/or grubbing operation are objectionable and should be removed and disposed of as specified in the contract. Disposal sites may be selected by the contractor outside of the state right-of-way limits, but should not be permitted unless the contractor has secured written permission from the landowner (not the tenant). The disposal site will be taken care of in a manner such that when completed it does not detract from the aesthetics nor the environment of the area as it existed before the project began.

Timber to be removed from the construction area may be of merchantable quality. Merchantable timber should be trimmed of all limbs and cut into log lengths, then neatly stacked out of the construction area, or disposed of as directed by the Standard Specifications, or Special Provisions. Timber within the boundaries of the National Forest is the property of the U.S. Government. Therefore, cutting, salvage, or disposal must be made at the direction of the forest authority. These officials should be contacted before clearing begins.

Burning of the combustible remains of clearing and/or grubbing operations when permitted by contract, is the most common method of disposal. Material to be burned should be disposed of in approved areas with adequate provisions made to protect the surrounding timber, grassland, and adjacent property. Burning material shall not be allowed to produce undesirable quantities of smoke except for very short periods of time when starting or stopping a fire. Burning is to be done in accordance with the laws and regulations of federal, state, and local governmental agencies having jurisdiction. Competent watchmen should constantly supervise the burning operation. It may be necessary to provide standby firefighting apparatus. Burning permits are required from the Director of Air Pollution Control and Industrial Hygiene, Montana Department of Health before burning slash and debris from clearing and grubbing can be done.

The burning permit will stipulate the conditions and method of burning. Two methods of burning are included in the Standard Specifications: Method 1, "The Air Curtain Destructor" and Method 2, "Forced Air Distribution". However, the contractor is encouraged to use other burning techniques as they become available. When Method 1 is used, the air curtain destructor must be approved by the Department of Health but only commercially produced destructors or destructors following approved, standard commercial design will be considered. When Method 2 is used, burning should be accomplished only when good smoke dispersing atmospheric conditions are forecast by the National Weather Service. The Standard Specifications give minimum pit dimensions to be used for Method 2. However, changes in pit dimensions may be made, at the discretion of the engineer, to produce more desirable results.

Improper clean-up of the area surrounding the burning site, lack of watchmen to control the spread of fire, or smoldering timber rekindled by high winds are some of the many causes of fires that spread beyond the intended burning area. Serious fires may spread, consuming many acres of valuable land, if the contractor loses control of its burning operation. In many locations, at times of hot fire danger, it may be advisable to wait for more favorable weather and ground moisture before burning is started. Do not allow debris to be burned near or under utility lines. Locate the burning site in the mid-area of the cleared tract and remove the duff and debris from around the site.

40.06 Hazards

Clearing and grubbing operations conducted in particularly dense, heavily timbered regions can be very dangerous work. Heavy branches thrown from swaying trees can travel great distances and inflict serious injury or death. Clearing equipment should be protected by canopies. The engineering personnel have to be especially careful when working in the vicinity of such clearing operations. Inspectors should be certain that the contractors operation does not endanger them, result in potential hazards to the traveling public, or create damage to existing facilities in or adjacent to the right-of-way. Clearing through extremely tall timber demands extra care, precaution and proper falling equipment.

Adequate provisions should be made to protect the traveling public when clearing or grubbing operations are performed adjacent to the present-travelled roadway. Proper construction signing, with flagmen and pilot car provided when necessary will help move the traffic, making the area safer and aid construction efficiency. When the contractor employs blasting methods as an aid in clearing the right-of-way, adequate construction signing and protection of the traveling public is a must. Radio transmitters can inadvertently send enough electrical energy to detonate the blast prematurely. Most contractors are aware of this possibility and will post signs prohibiting radio transmission in the blasting area.

Survey parties working in proximity to clearing operations should form their work schedules so there will be no danger of being struck by falling trees, flying debris or stump blasting operation. Hard hats must be worn by State employees who work in or near clearing operations.

40.07 Records and Documentation

Daily entries are to be made in the project diary by the engineer or inspector in charge of clearing and grubbing the right-of-way. Such information as the number of contractor's men employed each day, equipment used each day, date and location that clearing began, the number of acres cleared each day, or production rate and the dates and hours in which burning began and ceased are essential ingredients of a good clearing diary. Information regarding discussions with the contractor, when officials of other agencies have been notified of clearing, burning or protective measures and delays to the work from any cause, will contribute to proper documentation. If a fire should get out of control, a brief resume should be written into the diary stating the date and time the fire started and was controlled, the probable causes for the fire if known, and fire control methods that were employed as well as a description of the damage done.

The project file should contain the date and authority of any burning permits obtained, the contractors permit received from property owners for disposal of waste material outside of the right-of-way limits and a brief description of the location of these disposal sites this location should, where possible, be at least 300 feet outside of the right-of-way and out of sight of the highway. Any piles of merchantable timber are to have a written description placed in the project file regarding the location of each pile, property owners name, the approximate length and quantity of logs in each pile.

Change orders may be needed to provide for removal of unsafe trees outside of the clearing unit, or for additional clearing of areas outside the limits provided, or for other necessary work. The change order, when required for additional work should adequately describe conditions leading to the additional work and reasons why the additional work is deemed necessary. These change orders must receive the approval of the Construction Bureau for all projects and the Federal Highway Administration representatives for Primary and Interstate projects.

A notebook record is to be made on an area basis, percentage of lump sum or station to station quantities of right-of-way clearance performed. When a contract item has been set up to pay for right-of-way clearance, the notebook should show sketches and dimensions where applicable and reflect the quantity of work done each day or time period. When right-of-way clearance is to be absorbed in other contract items, no pay record is needed, but do keep a reasonable account of the contractor's time expended in clearing activities. If right-of-way clearance has been set up on an individual unit basis, the individual trees (units) are to be measured in place and proper notations made in the notebook to reflect the exact quantities cleared.

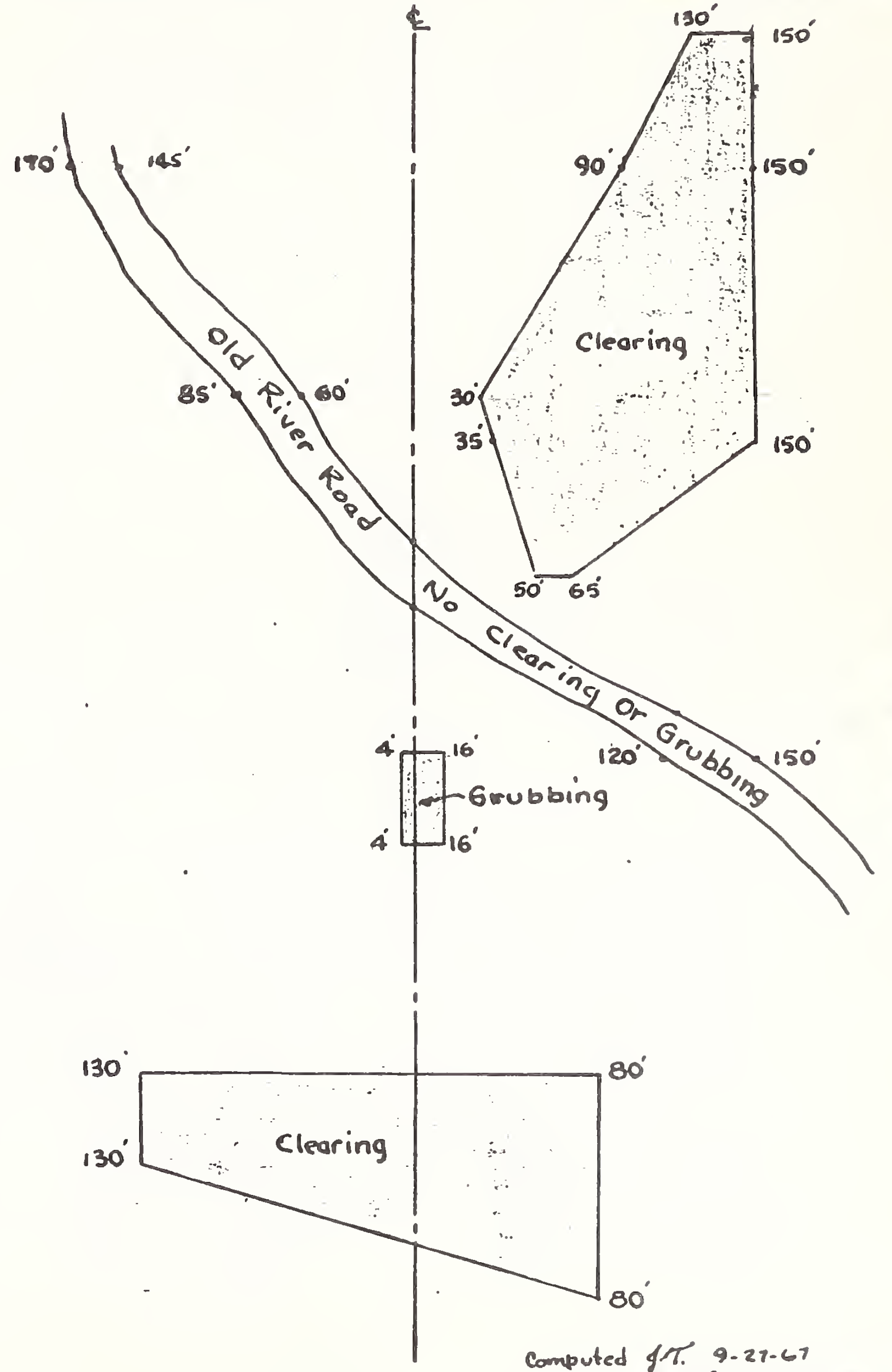
Figure 40-1 shows a sample set of clearing and grubbing notes. Variations may be made in the method of setting up the notes, but the general features of good notekeeping practice should be maintained. The sample notes shown are for clearing and grubbing contracted on an acre basis. The staking party information need only be shown on the first page of a days run in staking. The remaining pages for that days run need only show the staking date, page number and other data, not the staking party. The perimeter of the various areas to be cleared or grubbed is generally outlined by trees or brush. Stakes should be set at convenient locations to outline this perimeter. After staking is completed, the various areas should be computed and their quantities checked against the planned quantities of clearing and grubbing and any discrepancies resolved. The notes should be documented by the date cleared, the inspectors name, and the initials or names of personnel who made and checked the computations.

Contracts where clearing and grubbing is set up on a lump sum basis are more prevalent than those specifying an acre basis and documentation for pay quantities is more easily administered. Notekeeping for lump sum basis of clearing and grubbing should include stations or locations cleared each day and an estimate of the approximate percent of the total lump sum cleared or grubbed that day. This information should appear on the left hand side of the note page, the right hand side of the note page should include the inspectors name for that days work and his remarks concerning the clearing or grubbing function. If additional work, beyond the scope of the original lump sum item is necessary, a change order or extra work order on a force account basis may be used to allow this work. Contractors will ordinarily bid clearing and grubbing at a rate much in excess of the actual cost of clearing or grubbing. Therefore, it is essential to keep accurate day by day records of the contractor's men, equipment and operation in case of quantity changes or claims for increased compensation. These records can be placed on the right hand page in the clearing notebook. Accurate records of the contractor's men, equipment and operation serve three purposes. They provide thorough documentation to support the payments made; they provide the only logical basis for supporting or denying a contractor's claim; and they establish the firm basis needed for reviewing price offers for overruns or underruns in quantities.

Staked 8-8-67
J. Johnson & O. Freeman

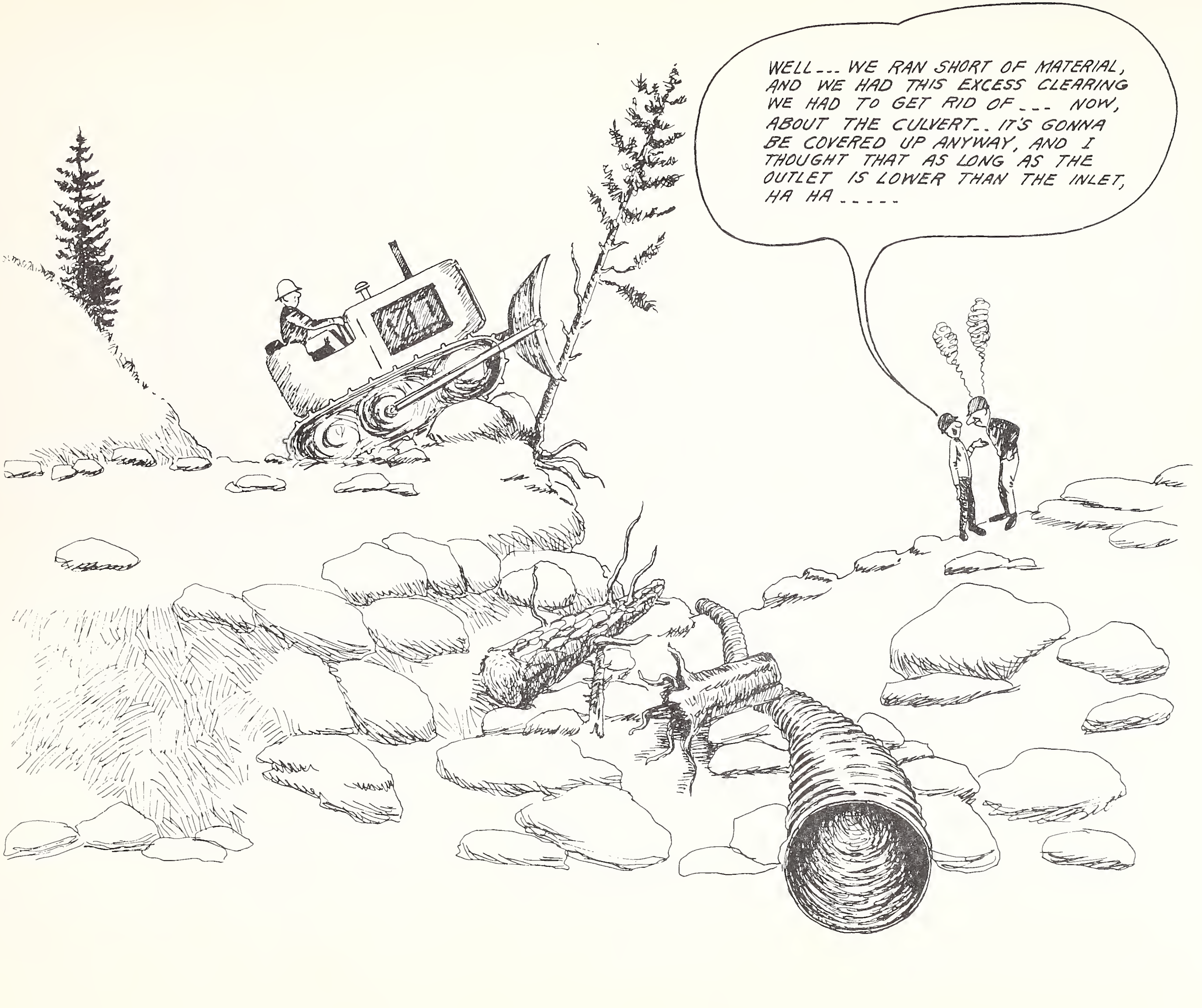
Inspected 9-25-67 10
Fair
James Taylor: Inspect.

Sta.	Clearing width	Clearing avg. width	Clearing sq.ft.	Grubbing width	Grubbing avg. width	Grubbing sq.ft.
500	20'					
498	60'	40x200	8000			
496	120'	90x200	18,000			
495+50	115'	117.5x50	5,875 ~~6,375~~			
494+20						
494	15'	65x150	9,750			
493+80						
493				20		
					20'x100'	2000
492				20		
489+90	210'					
		210'x90	18,900			
489	210'					
		185x100	10,500'			
488	0					
			71,025			2000



Computed J.T. 9-27-67
Checked Bill Brown 9-29-67
– Div. Office H.S. 11-15-67

Figure 40-1


WELL... WE RAN SHORT OF MATERIAL, AND WE HAD THIS EXCESS CLEARING WE HAD TO GET RID OF ... NOW, ABOUT THE CULVERT.. IT'S GONNA BE COVERED UP ANYWAY, AND I THOUGHT THAT AS LONG AS THE OUTLET IS LOWER THAN THE INLET, HA HA .....

IV-41 EXCAVATION AND EMBANKMENT

41.00 References

Standard Specifications: Sections 11, 12, 13 and 16

Construction Manual: III-30

41.01 General

Improved earthmoving equipment and methods have speeded grading operation in recent years to the extent that the Project Manager must make every effort to foresee conditions requiring changes in plans, the need of special construction procedures and day by day coordination with contractors and subcontractors. Delays in work progress must be avoided wherever possible as they can become costly to the State and to the contractor. The plans, special provisions, supplemental specifications, and soil report for each balance are to be thoroughly reviewed by the Project Manager and his inspectors. A careful comparison of the preliminary soil studies with actual findings is necessary to provide adjustments in the work that will make the best usage of materials available. Variations in drainage, changes in the backslope design, grade or surfacing depth may be made as the work progresses. Each new cut must be examined as soon as possible after it is opened so that necessary changes may be made before the excavating equipment has moved out of the area. A few auger holes may be made in the sub-grade to compliment the visual inspection and to determine if objectionable materials are present. An unstable sub-grade can result from excessively high natural soil moisture, high water table, excessive concentration of organic materials or soil which promotes frost heave, such as silts, and very fine sands. The assistance of the Division Materials Supervisor is to be requested in the event such unstable conditions are discovered.

The Grade Inspector should possess knowledge of the capabilities of the various types of equipment used by the contractor. The contractor's schedule, location of haul roads and blasting. Generally, the contractor will select equipment best suited to the type of material to be excavated, the steepness of grades and the length of haul. For example, crawler type tractors and scrapers are used for steep grades and short hauls, high speed two or four wheel rubber tired tractors and scrapers are used for medium to long hauls. Whereas, trucks, loaded by shovels, elevating graders or front-end loaders are used when legal load limits are imposed or excessively long haul distances exist. The use of the end results specification (sub-grade compaction) has induced contractors to use a wide variety of compacting equipment for Montana's highway construction program.

Many roller types will effectively compact one material, but become inefficient or are unable to compact another material. It is the contractors choice of whether to use a sheeps-foot, rubber tired, vibrating, grid or segmented wheel roller. However, it is the inspector's responsibility to be certain that satisfactory results are being obtained, no matter what type of roller is used. The roller used must be capable of compacting the proper lift thickness to the required density at the desired moisture content. The number of rolling units needed are in a direct relationship with the production rates of the excavating and hauling equipment. A contractor's operation must, therefore, be balanced so that no more excavation is hauled than can be efficiently and properly compacted.

41.02 Preparation of the Roadway Foundation

A. Removing Topsoil

A record of the soils profile prepared from tests of samples taken from borings should be reviewed to determine the depth and existence of top soil and for knowledge of other deeper soils conditions throughout the job. Top soil is to be removed from excavation and embankment areas as needed and later placed over the backslopes, ditches, inslopes, channel changes and construction areas where insufficient top soil remains, such as obliterated roads etc. Top soil is to be obtained from within the right-of-way limits at all times, unless exceptional conditions require top soil removal from other areas adjacent to the project. Random stripping of top soil from areas within or outside of the right-of-way must be discouraged. Top soil is to be placed at strategic locations that will permit easy placement of the top soil over the finished slopes but the stripping operations and stockpile sites must receive the Project Manager's prior approval.

Assistance should be given the contractor in the selection of suitable stockpile areas. Areas that will minimize the haul involved and not interfere with or delay other construction operations during the top soil work are most desirable.

More than casual inspection should be given to the top soil stripping and stockpiling operation. Excavating too deeply will easily yield the estimated quantity, but the quality of this top soil may be deficient in soil nutrients. Shallow stripping may glean the majority of soil nutrients available, but may cause the estimated yield to suffer. Use a depth that will satisfy quantity and quality, an estimated total of stockpiled top soil based on load count or other methods may be maintained to insure that a sufficient quantity of top soil exists before beginning excavation and embankment construction, but each stockpile is to be measured to accurately determine pay quantities.

Top soil, furnished by the contractor from sources outside of the right-of-way, will be measured by the cubic yard of loose material, level with the box in the hauling vehicle, at the point of placement on the project. This material must meet the requirements of Sub-Section 17.00 of the Standard Specifications.

All objectionable course vegetation is to be removed from the natural ground before stripping top soil. Be sure that stockpiles of top soil are located so that drainage is not blocked.

B. Cut to Fill Transitions

Preparing the roadway foundation includes removal of objectionable material from cut and fill sections, determining that clearing and grubbing has been satisfactorily completed, and assuring that the natural ground under embankments and through cut sections will provide adequate support for the overlying road.

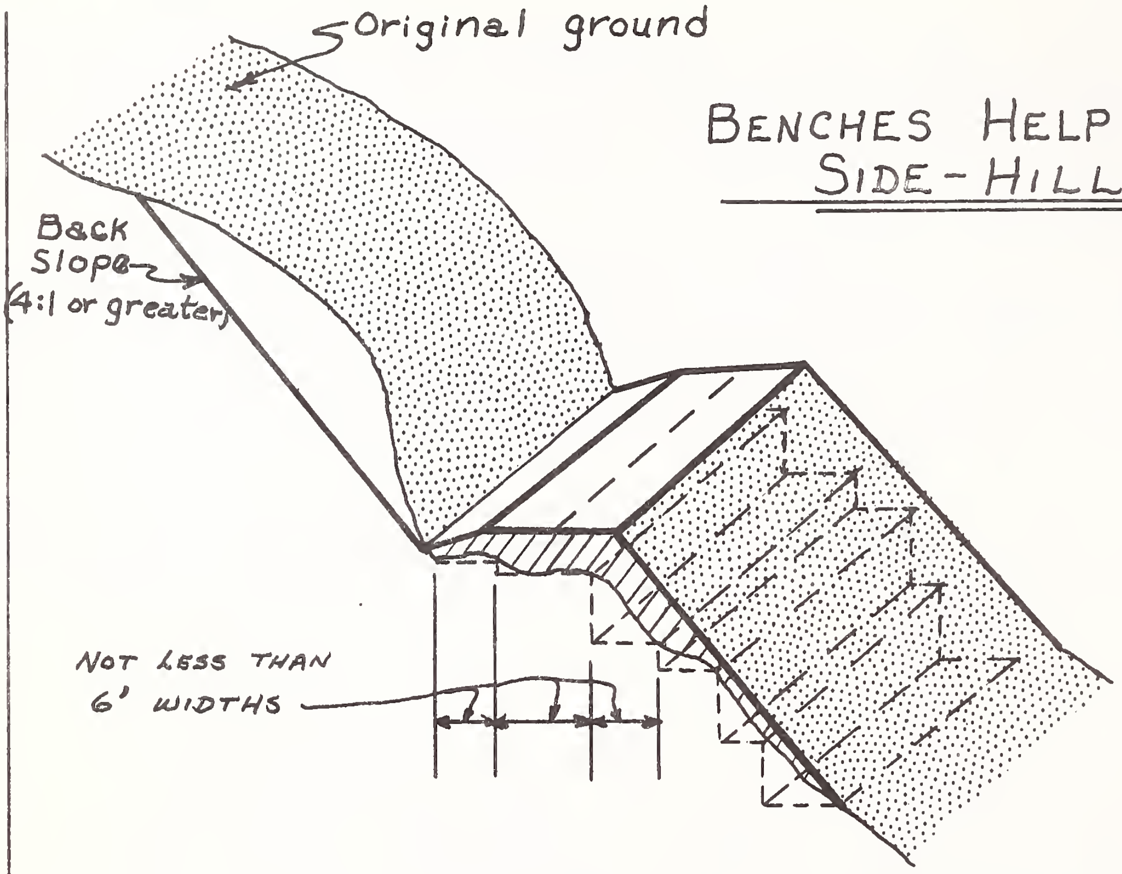
Transition sections (where the grade line changes from cut to fill) should be under-cut and re-compacted as necessary to provide a firm keyed foundation. The undercutting should result in a reasonably good transition and the removed material, if satisfactory, roadbed material, may be recompacted along with the embankment material. The depth of undercuttings should be approximately three feet below sub-grade and extend as far under the cut as it does under the fill, where practical.

Continuous benching, Figure IV-2, may be performed in the cut to fill transition area to prevent slip planes from forming. The benches act as keys and are to be used when natural ground slopes are steeper than 4 to 1. If benching is used, the top bench should terminate at a point approximately three feet below subgrade elevation. The benches must be properly compacted and the material cut out of the benches, if acceptable, may be put into the new embankment.

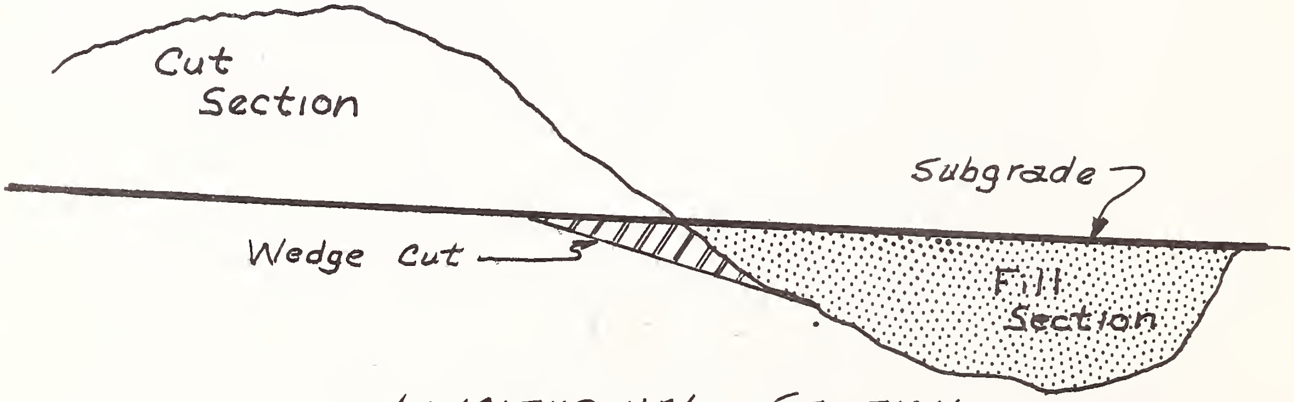
C. Embankment Foundation

The natural ground forming the foundation for roadway embankment is to be cleared of objectionable material

BENCHES HELP STABILIZE SIDE-HILL FILLS



TRANSVERSE SECTION of ROADWAY



LONGITUDINAL SECTION of ROADWAY

WEDGE CUTS HELP REDUCE SETTLEMENT AT CUT-FILL TRANSITIONS

FIGURE IV-2

and vegetation, then compacted to the specified density for a width equivalent to the width of the sub-grade. Should lightly compacted soils, such as plowed fields, be encountered beyond these limits, the engineer may direct compaction work be performed outside sub-grade width, which shall be measured and included for payment.

Areas beneath the proposed embankment containing muck or compressible material should be excavated to the solid earth when the depth to a solid foundation is not excessive and when excavation is more economic than other corrective measures. If potholes are wet after removing the unstable material, this excavated area should be backfilled with granular material. Areas under the proposed embankment containing a series of sharp knobs and depressions should have the knobs leveled and the adjacent holes filled and adequately compacted before resuming embankment construction. Similarly, roads and trails made for the contractor's convenience that underlie the proposed embankment, if not properly compacted, should be re-worked and recompacted from the bottom up before embankment operations are allowed to proceed over these trails.

Haul roads across gullies and similar trails built for the contractors use may not require total compaction for their use on a temporary basis. Therefore, proper compaction may not have been achieved. As a result, very serious settlement has occurred on some newly constructed roadways due to insufficient compaction of underlying haul roads.

Each ravine, hillside and drainage course traversing the embankment area should be thoroughly inspected for seepage, springs, lush growth of vegetation or other indications of ground water.

Every hillside in or adjacent to the right-of-way must be thoroughly inspected for evidence of landslides. Rolling terrain in an otherwise smooth landscape is a possible indicator of landslide activity. Trees or brush leaning downhill indicate slippage of the surface mantle. Twisted trees, disconformities in fence or pole lines or lack of vegetation in otherwise timbered areas are other indicators of slides. Occasionally clues are inadvertently missed in the location and design stages and it is, therefore, necessary that every effort be made to discover landslides or impending slides before excavation has begun. Protective or corrective measures can then be taken with little or no increase in cost. The engineer who lightly assumes that every cut slope will remain contently in place may be abruptly surprised and sadly lacking in comment when a hundred thousand yards or so of angry earth swiftly eradicates his well staked plans.

D. Sub-grade In Cut Sections

The subgrade in finished cut sections will require special attention. Alternating layers of expansive and granular soils may require mixing and recompaction to provide uniformity; or the expansive material may need to be removed and replaced with adequate soils. Hard materials may exist in the midst of acceptable, but more compressible material, and since the compressible material will consolidate with time, bumps may occur in the pavement. These harder materials, when encountered should be excavated and backfilled with uniform material. If consolidation then occurs it will happen more uniformily as a unit.

The finished sub-grade through cut sections must receive as much inspection and density testing as the adjacent embankments but is often neglected. Cut section sub-grades may be at the proper density and moisture content without compaction, but may not be uniform. Sub-grades composed of different materials may expand or swell at different rates causing humps in the completed road, so scarifying and blending should be required of such sub-grades. When sub-grade compaction is a contract item, but the sub-grade through cut sections is at the proper density, when excavated, the contractor may not want to do the necessary compaction, yet want payment for this work. Remember, it is the contractor's responsibility to furnish an adequate sub-grade that will support the pavement structure and properly distribute wheel load without undue distortion. The statement "no work, no pay" should squelch this contractor's request.

The Standard Specifications provide for excavation to approximately 6" below sub-grade when rock is encountered in the cut sections. The intention of this requirement is to provide a protective cushion between the finished pavement and the underlying rock. Isolated outcropping of rock or portions of large boulders which protrude above the sub-grade elevation should be removed to a depth of not less than 6" below the sub-grade elevation. The low areas caused by removing such rock should be backfilled with suitable material. All backfilling should be done, of course, to the proper moisture and density requirements.

Large stones or broken rock should be removed from the top portion of the subgrade and the stability of the subgrade maintained until the sub-base aggregates or pavement can be placed.

41.03 Excavation

A brief description of roadway excavation is, removal of a sufficient quantity of suitable material for use in building a satisfactory road bed. During the excavation process excess or unsuitable materials may be encountered and an acceptable place must be found for their disposal. Disposal areas are to be neatly blended with the roadway and adjacent landforms and side slopes must remain stable after construction. The excavated material is most usually obtained from the roadway prism but may also be taken from borrow sites, channel excavation areas, or from street sections.

A. Prewetting Excavation Areas

It is at times helpful and expedient to uniformly water the excavation area prior to removal of the material. Prewetting reduces the need for machine manipulation of the soil after it is placed on the road bed because a more uniform distribution of moisture can be obtained by prewetting, providing that the soil is conducive to prewetting. The areas to be prewet should be ripped, along the contour of the ground, to an approximate depth of 2 feet on approximately 4 foot centers. This will provide for better penetration and decrease run-off. It is generally uneconomical to attempt to prewet heavy clay soils, because these soils will readily shed water acting as a natural water barrier. Water is best incorporated into heavy clay soils by sprinkling and mixing on the grade. Heavy disks or harrows may be needed to break dry clods to aid in mixing in water or similar forming methods may be used. Time is needed to obtain uniform moisture distribution and a lift thickness much in excess of 6 inches loose measure will become increasingly difficult to work, thus adding to the time.

Best results for getting a uniform moisture distribution in medium clay soils is most readily obtained with sprinkling followed by mixing with disks, cultivators or rotary mixers. These soils will react similarly to the heavier clay soils but will allow somewhat more water penetration following a prewetting operation.

Sandy soils and friable (crumbly) silty soils will take water readily and can therefore be easily prewet at the excavation site. Prewetting should be done over a period of a few days to a few few weeks in advance of excavating and compacting, depending upon the texture and compactness of the soils in place. The longer time intervals allow water to be more uniformily and thoroughly dispersed throughout the soil. Prewetting should be controlled so there is no run-off, which could cause erosion and silting of the adjacent land.

B. Unsuitable Materials

The Standard Specifications describe as unsuitable, those soils that cannot be properly compacted in embankments; or where excavation to finished grade results in a roadbed of muck or other unstable materials.

Much of the unsuitable material encountered during excavation cannot be anticipated in the original plans, but the engineer should never hesitate to require removal and disposal of unsuitable materials just because the plans did not so specify. The depth to which excavation should extend when removing unsuitable materials must be determined on the job by the engineer and should be deep enough that the bad material is removed whenever economically feasible. Some soils encountered would be unstable and, therefore, unsuitable when in their natural state because of excessive moisture, but many of these soils will respond to drainage or mechanical manipulation to reduce moisture, thus improving the soil and rendering it suitable for use.

Many soils such as, peat, mulch, some silts, and some highly expansive clay soils are unsuitable because of their natural composition. They are considered unsuitable because they may become unstable in the embankment or have some other detrimental effect and are normally wasted, used to flatten the slopes or in some cases used for top soil. However, the detrimental effects of some of the less suitable soils may be minimized by placing these soils near the bottom or lower center of embankments. By utilizing those soils in that manner the surface loading pressure may be reduced and the flexing action, which it would be exposed to if it were nearer the surface of the embankment, is decreased.

Full consideration is to be given to making the best possible use of any soil material encountered in the excavation, since it is the intent of the specifications that all usable excavation be placed in the embankment.

It is sometimes necessary to use silts and expansive clay soils when they are the only types available for road construction in the area. Silts may cause tremendous heaving when freeze-thaw cycles occur and should be placed below the frost line if at all possible. Expansive clay soils should be placed at a moisture content slightly above optimum where possible and should be further protected from any future change in moisture content by membranes or inslope protection when such treatment is economically feasible. Soils that are borderline may be used to construct solid roadbeds if they are properly selected and placed in locations that will lessen their undesirable characteristics; or these soils can be mixed with better soils to increase their stability.

Clay shale and shale materials are unsuitable as a subgrade because of low shear strength and high swell potential. In cut sections the swell problem is much greater because of the high undisturbed density. Corrective procedures in this situation are usually subexcavation and replacement with non-swelling material or placement of an asphalt membrane over the sub-grade to prevent intrusion of moisture from the surfacing materials into the sub-grade and to maintain a constant moisture content in the sub-grade.

When these types of soils are encountered below subgrade in cut sections and the plans do not call for sub-excavating,the Division Materials Supervisor should be notified and an investigation made to determine the depth this material should be sub-excavated and the type of backfill to be used.

C. Excess Materials

Material excavated to grade in cut sections and then transported to the fill sections might not stay at a constant volume after compaction. Increases in volume are called swell and decreases are called shrink. The engineer must compare the shrink and swell factors of actual construction quantities with the preliminary quantity calculations, as soon as possible after staking. Then any necessary changes in the grade or alignment, wasting or borrowing and adjustments in haul can be made in time and without construction delays. The terrain and suitability of locally available materials may require that a project be planned for borrowing and wasting of material rather than balancing the cut with the fill material. In such cases, disposal areas and borrow sites will have been previously established. However, when no provision for disposal of excess material has been provided for in the contract and excess material does exist, the Project Manager must make the necessary arrangements for obtaining the use of the disposal areas. These arrangements should include notifying the right-of-way section so they can negotiate an agreement with the landowner for disposal of material outside of the right-of-way. The Division Supervisor should be informed of the need to dispose of excess material as soon as the Project Manager is aware of this need.

When it is known that an excess of material will occur or is occurring, grades may be changed and alignment adjusted to accommodate the excess material providing that adequate sight distance, drainage, and proper safety features are maintained. Excess material may also be placed along the side of an embankment to widen fills uniformily, or it may be used in constructing turnouts, scenic viewpoints, or similar facilities. Surplus materials may also be placed between the embankment and right-of-way line or in loops and gores of interchange areas. Disposal areas should be selected so that drainage will not be impeded and so the appearance of the whole facility will be improved and will become a benefit for future development.

Care must be taken to minimize embankment erosion when excess material is used to widen the embankment slopes. Wherever possible, widening is to be made along with the original embankment so that proper compaction is obtained. Loose material should not be dumped on slopes of high embankments.

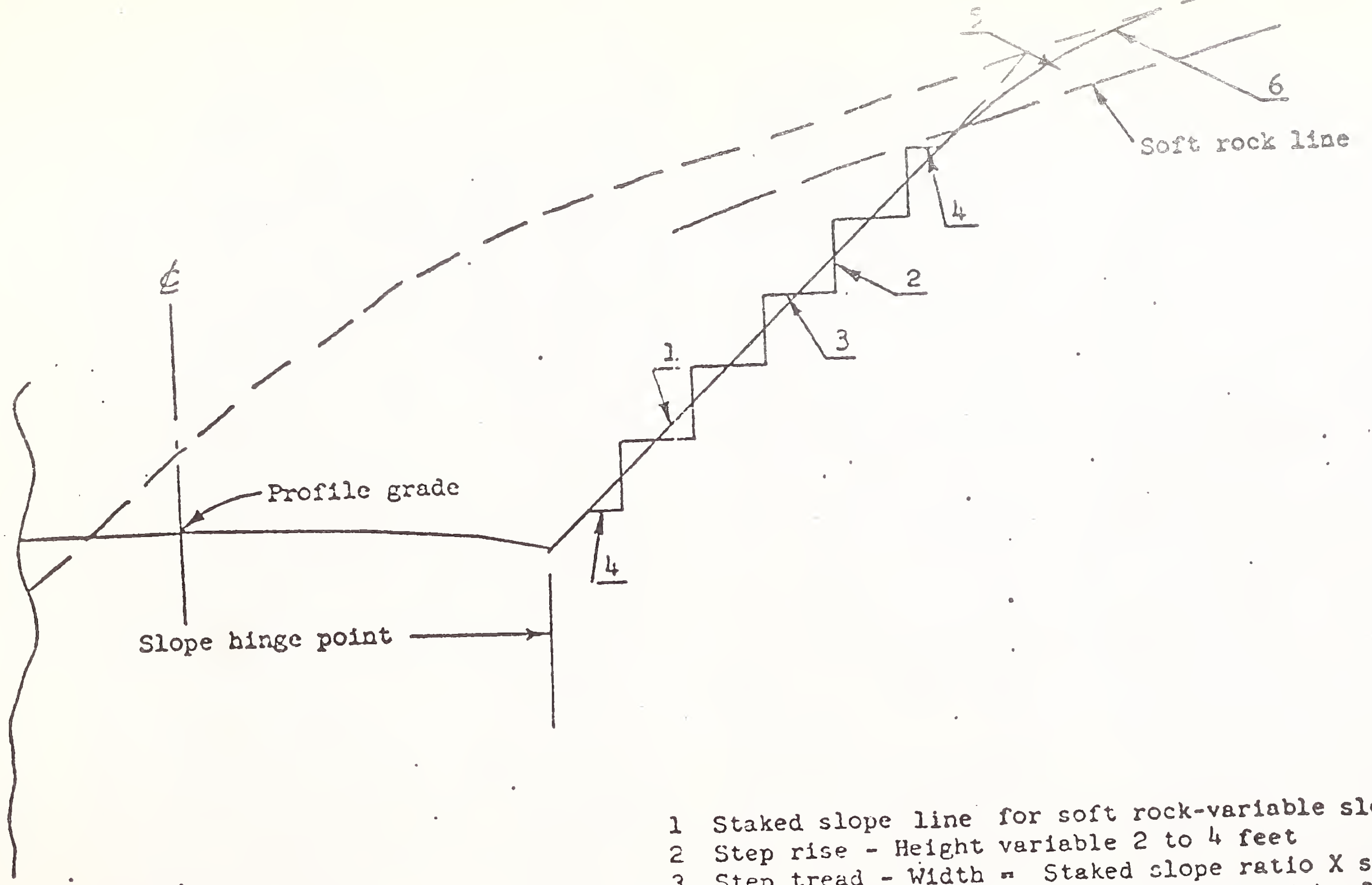
D. Slopes

The increasing emphasis placed on beauty and natural appearances require that inslopes, backslopes and ditches are constructed in pleasing rounded shapes and made to blend with the natural adjacent landscape. Rounding of the tops and ends of cut slopes can be done most economically and effectively during the progress of the work when these areas are easily accessible. The requirements for aesthetic backslope construction should be thoroughly discussed with the contractor's representative, and if possible, described to the men doing the actual work.

Slopes should be constructed according to the plan requirements, but the degree of slope may be changed because of excessive rock slides, potential slides, ground water, or other similar unsatisfactory slope conditions. When slope instability is anticipated, the problem should be thoroughly discussed with the Division Construction Supervisor and FHWA officials and corrective measures taken as rapidly as possible. The need for rapid action hinges on keeping the cost of corrective measures within reasonable bounds. Every cut slope and the natural ground behind cut slopes should be inspected for visible signs of distress as excavation progresses.

All finished slopes are to be viewed for their appearance. Slopes that have been properly formed will have had the correct quantities removed and yet will present a neat appearance. Errors, carelessness, or the nature of the material being excavated can cause such deformities as humps, knobs, slides, or overbreak. Overbreak can occur when material which is excavated is displaced or loosened outside of and beyond the stakes slopes. Land slides will not be classified as overbreak. The various deformities that may occur during backslope construction can usually be prevented with careful inspection during the construction process.

Serrated slopes may be specified on the plans for large cuts consisting of soft rocks. Serrated slopes are nothing more than horizontal steps constructed into the slopes as the excavation is being performed. (See Figure 41-3). The steps may vary from 2 to 4 feet, vertically, with the horizontal dimension being a function of the staked slope ratio. The approximate midpoint of the horizontal tread of the step should be constructed on the staked slope line with the top step beginning just below the soft rock line. The steps should be constructed approximately horizontal rather than parallel to the centerline grade. Excavation of each step should be in the opposite direction from the preceding one to minimize buildup of loose material at the ends of steps, loose material which collects at the ends of steps should be removed and the ends blended into the natural ground. Where rock, too hard to rip, is encountered within a cut, the steps should be blended into the rock.



1 Staked slope line for soft rock-variable slope ratio
2 Step rise - Height variable 2 to 4 feet
3 Step tread - Width = Staked slope ratio X step rise
4 Step termini - Width = ½ step tread width 3·
5 Overburden area - Variable slope ratio
6 Slope rounding

TYPICAL SECTION
FOR STEPPED SLOPES
IN SOFT ROCK

Figure 41-3

E. Types of Excavation

1. Unclassified Excavation

The characteristics of each material being excavated remains unclassed in the contract. Therefore, rock, clay, sand, gravel, and other materials whether mixed or encountered separately will be removed and disposed of as specified under one bid item and at one unit price. The majority of construction contracts have the excavation item described in this manner as unclassified excavation.

2. Borrow Excavation

Borrow excavation is usually separated into two categories one is called unclassified borrow and the other category deals with special borrow. Sources from which borrow material may be obtained occur near the right-of-way or may be found many miles from the construction site. Unclassified borrow is similar to unclassified excavation in that a quantity of earth material must be moved from its present location to its constructed position in the roadbed. Unclassified borrow material is generally suitable for embankment construction as mother nature has placed it, whereas special borrow material may have gradation requirements to be met and is generally selected for use in a particular area on the project.

3. Channel Excavation

The proposed highway improvement may traverse many areas containing natural or man-made waterways, channels, irrigation facilities, or other hydraulic involvements. River channels may need to be straightened, deepened, widened, or completely changed. Inlets and outlets to culverts or similar drainage structures may be required, all of which would result in a certain quantity of material being excavated.

Channel excavation when required will be listed in the contract as unclassified excavation and described on the plans. Payment as "channel excavation" can only be made when this item appears in the contract, the work is designated on the plans, and bid upon by the contractor.

4. Street Excavation

Measurement and payment for excavation occurring in city streets sections or sections of a similar nature on public highways may be established under a contract item either street or unclassified excavation. Street excavation will then describe the excavation and removal of all material required within the specified section. The process of excavating for the proper street section is more refined work requiring more precision and attention to such various details as utility locations, manholes, sewers, and storm drains, and will, therefore, be more costly than the normal unclassified excavation work of highway contracts.

5. Subcut Excavation

Very few highways are constructed without encountering materials in their natural state that are unsuitable for highway construction. These unsuitable materials are generally more costly to remove and dispose of due to the special equipment required to perform the work. Therefore, subcut excavation is considered an individual item when it appears in the contract.

Subcut excavation consits of removing and disposing of unsuitable material from below sub-grade elevation in cut sections or from below the natural ground line in embankment sections.

41.04 Blasting of Rock Cuts

A. General

Where the natural ground consists of rock that can not be ripped, blasting techniques are necessary to fracture the in-place rock to the necessary size for handling with road equipment and for construction of good embankments.

The rock area to be blasted is first cleared of all overburden soils, trees, etc. and work roads constructed to permit access of the rock drills. Normal operations employ a track mounted unit to drill the production blast holes. Spacing of the drill holes into a regular pattern that will give optimum breaking with a minimum powder charge to the in-place rock with no damage to the planned cutslope is the objective of the primary blast. Commonly used terms used in blasting are as follows:

Burden - The shortest distance from a free face to the first primary hole or holes. Burden distance should be about 2/3 the spacing distance.

Hole Spacing - Distance between holes measured perpendicular to the burden.

Powder Ratio - Is the total powder explosives used divided by the total cubic yards of rock in a given blast. This ratio generally runs 0.5 - 0.75 lbs/yd.^3

B. Presplitting

Where it is desirable to produce a smooth cut face with a minimum of blast damage, presplit blasting techniques may be specified. Presplitting is most commonly employed in the harder rock types such as granite, basalts and layered rock-hard shales, sandstones, limestones, argillites.

Presplitting of rock cuts consists primarily of drilling a series of close spaced parallel holes (usually 30 inches apart or less) that will reasonably conform to the designed cut lines and grade. Presplitting operations are performed prior to the primary blast. This method provides a presheared face for the primary blast to break into and permits escape of blast hole gases and energy. Controlling the loading of these holes, the firing sequence, and hole spacing, a smooth plane should be produced from one hole to another along the presplit fracture plane without damage to the backslope outside the excavated limits.

Normal presplitting operations will begin on a trial and error basis using the initial given trial blast program. After the first presplit blast, the condition of the rock face should be checked. Modification or adjustments can then be made to control poor presplitting results. Excessive rock fracturing as evidenced by fracturing outside the neat line may necessitate one or all of the following:

(1) Reducing the powder charge

(2) Changing the hole spacing

(3) Decreasing the powder charge spacing or redistribution of the charge in the hole.

C. Blasting Record (Form CSN55)

Attached is the blasting record Form CSN55 for use by project personnel. Collection of this data will help evaluation of the effects of blasting on construction, stability and appearance of rock cuts and provide information for future use in construction and design. The following description of terms and attached sample of a completed blasting record Form CSN55 is enclosed for your information. (Fig. 41-4)

Lift Number - Place number of presplit lift starting with No. 1 at natural ground level.

Hole Attitude - Show degrees from vertical holes that are being drilled such as vertical: 14° (corresponds to ¼:1 slope); $26\frac{1}{2}^{\circ}$ (corresponds to ½:1 slope) etc.

To the right of the space for hole attitude; circle one or two appropriate directions that show the direction the bottom of the hole slants. Ⓢ Ⓔ southeast or Ⓝ Ⓔ for northeast, etc.

How loaded - Show the distribution of the powder charge within the hole and if the charge is in every hole - Example - every other hole loaded at ¼ lb. of 40% extra strength dynamite per lineal foot.

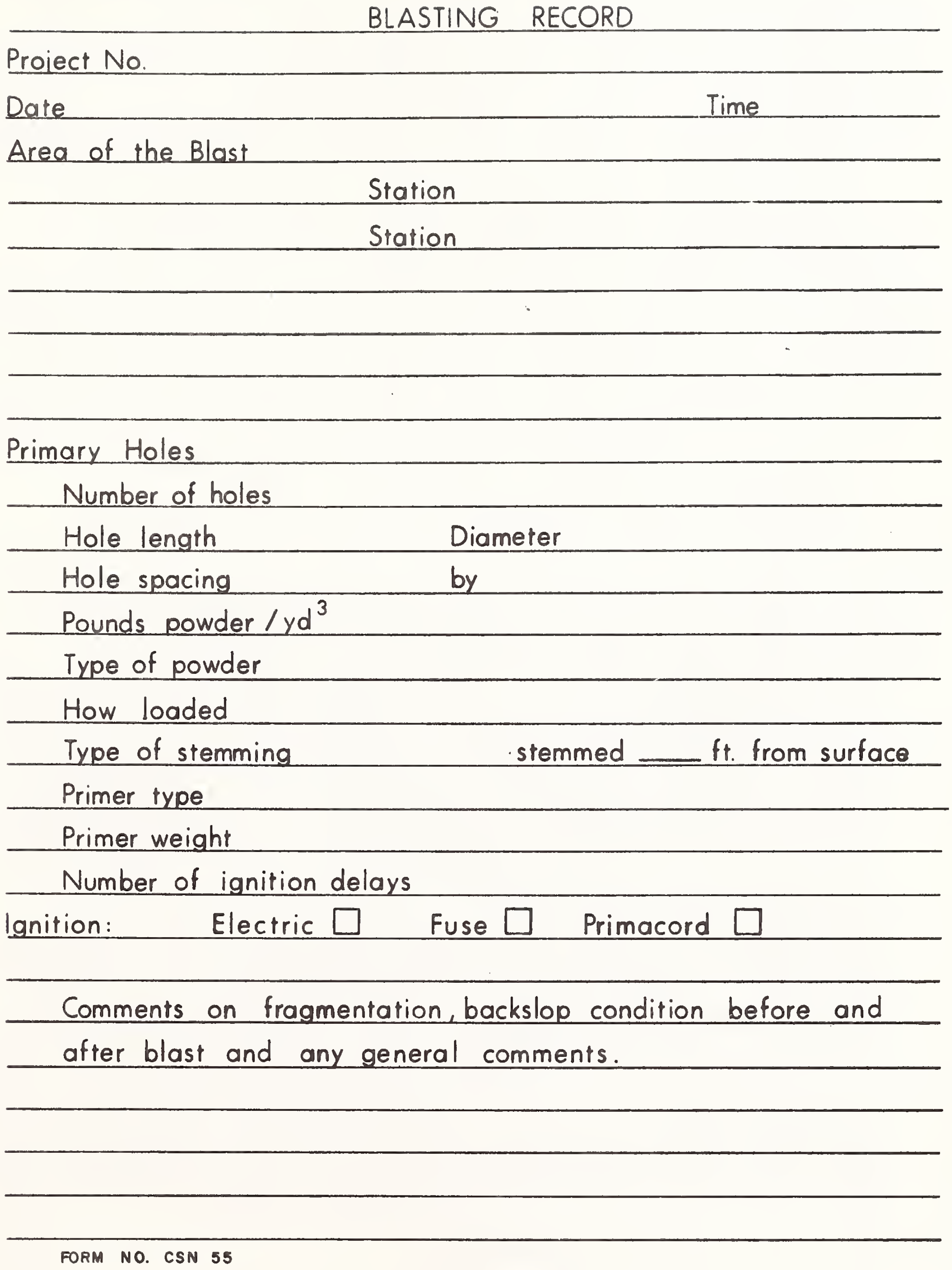
Sketch of primary and presplit ignition sequence - show and number the sequence of the primary blast. Sketch the free face, stationing, centerline of road and location of the presplit holes.

Any questionable terms are defined in a standard blasting handbook.

Undoubtedly through use we will find areas in this form that could be improved upon. We would welcome suggestions from the people involved after a limited period of use.

The Geology Section of the Materials Bureau is to receive a copy of the completed form after each blast from the Project Manager. Forward to:

Geology Section
Materials Bureau
Department of Highways
Helena, Montana 59601



BLASTING RECORD

Project No.

Date Time

Area of the Blast

Station

Station

Primary Holes

Number of holes

Hole length Diameter

Hole spacing by

Pounds powder / yd^3

Type of powder

How loaded

Type of stemming stemmed ____ ft. from surface

Primer type

Primer weight

Number of ignition delays

Ignition: Electric ☐ Fuse ☐ Primacord ☐

Comments on fragmentation, backslop condition before and after blast and any general comments.

FORM NO. CSN 55

Figure 41-4

HOLES Page No.

Presplitting Record Lift No.

Number of holes

Hole length Diameter

Hole attitude N S E W

Hole spacing

Pounds powder / linear foot How Loaded

Powder type

Stemming

Position

Station to

How ignited ☐ Electric ☐ Fuse ☐ Primacord

Distance to closest primary hole

Sketch showing primary and presplit ignition sequence, position of free face and back slope, direction of hole spacing

	Date
Entered By:	
Figured By:	
Checked By:	

FORM CSN

Figure 41-4A

41.05 Embankments

The original ground beneath embankments is compacted to improve its ability to support the embankment, and since the success of embankment construction depends to a large extent upon original ground preparation, inspection of the original ground underneath the embankment must be among the first phases of inspection prior to embankment construction.

The choice of construction methods and equipment are generally left to the contractor's discretion provided that methods are chosen which insure uniform material, proper layer thickness, adequate moisture content and uniform compaction. The amount of inspection needed will depend primarily upon the size of the project, nature of the soils, and the rate at which material is being placed. Inspection personnel should review that area over which construction operations will proceed and replace or reset any stakes that are disturbed or destroyed.

Embankment construction generally begins with filling the low areas, washes or holes first and then bringing up the first lift of embankment. The first lift of embankment spread over low areas may be slightly dished, but the intent is to eventually provide an embankment layer approximately parallel to the finished grade with each successive lift of embankment. Frequent checks should be made to see that the work conforms to the proper cross section, that large roots or other organic materials are being removed and properly disposed of, that drainage facilities are open and that the embankment site is in the best condition possible to provide maximum run-off from storms. All temporary and permanent erosion control features should be installed wherever they are needed to protect newly constructed slopes.

The construction hauling equipment should be routed in different paths when hauling to and from the embankment placing site. This hauling procedure is particularly necessary when hauling over expansive clay to avoid ruts or over compaction. Uniform compaction is ordinarily best obtained when the embankment layers are relatively thin, usually less than 8" in loose depth. When the proper amount of moisture is uniformly distributed through the embankment layer, little difficulty will be encountered in obtaining proper compaction, provided the thickness of the layer does not exceed the capabilities of the roller being used. It is common tendency to construct earth embankments at moisture contents on the dry side of optimum, but this practice makes the task of securing uniform moisture and satisfactory compaction more difficult and is not a desirable condition. Generally, it is better to begin compaction with the moisture content at optimum or very near optimum. In this way the contractor is required to provide the proper moisture content and distribute this moisture uniformily in the embankment material in order that his compaction operations will proceed with the utmost efficiency.

In order to insure uniform moisture content and compaction, each layer of embankment material that is not rock or gravel should be worked with a tandem type disc that will penetrate the full depth of the layer being placed and satisfactorily work moisture into the soil, break down clods and disorient soil particles. Plastic clays may require more disking and turning of the soils, to satisfactorily blend moisture, than the lighter soils.

Several light applications of water are more desirable than one heavy application. The frequent light application will allow better moisture percolation through the soils and provide less opportunity for the soil to become rutted and muddy. Care must be taken when adding water to a layer of soil to avoid overlapping or to allow gaps between successive passes of the water wagon. Excessively wet or dry stretches are undesirable. The water truck driver should work progressively from one side of the fill across to the other side to avoid having wet or dry streaks in the center or edges of the embankment.

A. Rock Embankment

The Standard Specifications provide varying construction methods when soils with different characteristics are encountered. For instance, embankments constructed wholly or partly from rock fragments offer a different challenge to the road contractor, because of the size, lack of fine material, and the general nature of rock embankment construction. The lift thickness may be increased from the specified 8" loose depth for each layer when the lift contains a quantity of rock pieces that are larger than 6" and these pieces comprise more than 25% of all of the rock fragments. Lift thickness should be kept to the approximate average size of the larger rocks provided, however, that in no case shall the thickness of layers before compaction exceed twenty four inches.

Even though the thickness of layers is limited, the placing of larger individual rocks is permitted providing, they are carefully distributed throughout the lift and do not exceed a height of forty eight inches.

Hauling vehicles should dump rock fragments adjacent or near to the final position. A dozer or another piece of leveling equipment can maneuver the pile of rock into its proper position at the correct lift height in the embankment. By exercising skill, the coarse and fine materials can usually be distributed so that void spaces that will be filled with small stones and earth to make the embankment as dense and compact as possible. Material should not be allowed to roll in place by dumping over the edge of completed work. However, when end-dumping is the only work method that can accomplish embankment construction over poor foundation soils, this work should be accomplished by dumping on top of the layer being built then shoving ahead with a bulldozer on as flat a slope as possible from the top of the lift to the natural ground, maintaining a lift no thicker than required to support the bulldozer at the end of the slope.

The last two feet of rock embankment below sub-grade elevation should be constructed from the finer materials where at all possible.

Excessively large rocks are to be broken into smaller pieces and these pieces uniformily distributed throughout the fill. When an excessive quantity of large rocks, occurs, it is best to place these rocks near the toe of fill slopes. They should not be placed in piles but separated, then the remaining embankment lifts can be properly constructed in layers around these larger size rock. If rocks and boulders are of such a size and shape an can be placed in reasonably uniform layers to permit rolling, rolling should be done with a grid or smooth-wheel roller. Sheepsfoot or pneumatic rollers do not perform well on rock embankments. When a large percentage of the bigger sized rock is present, moisture and density controls of the earth portion are generally impractical.

B. Earth Embankment

Some years ago new highways were constructed with a temporary asphalt surface. A few years later, after settlement of the fill had occured, a hot, plant-mix surface was constructed to provide a permanent high-quality riding surface. Roadways constructed in this manner have been quite successful in providing a long lasting smooth surface. However, highway needs require completion of new facilities as rapidly as possible. Many roadways are surfaced in the same construction season that embankment and sub-grades were completed. This accelerated rate of construction makes it increasingly important to maintain rigid control of the embankment compaction from the natural ground to the finished surface. Density and moisture must be correct and especially, they must be uniform. Excessively deep layer placement must be avoided, and continual visual inspection is to be made of compaction and embankment construction methods and equipment.

The Project Manager and his inspectors should understand thoroughly such compaction control procedures as in-place density tests, maximum density and optimum moisture curves, the one-point Proctor test, and the compaction process in general.

C. Embankment Over Swampy Areas

Special construction techniques may be needed to construct embankment over swampy ground. The lift thickness may be increased to a size capable of supporting the hauling and spreading equipment or end-dumping may be permitted in lieu of layered construction. It is the contractor's responsibility to select the type of equipment and method of construction which will least disturb the soft foundation, but maintain the proper compaction in succeeding lifts of embankment. It was previously stated that the lift thickness of 8" may be waived in the first layer in order to permit a thickness capable of supporting construction equipment across soft ground. However, the remainder of the equipment is to be constructed in layers of the proper thickness and is to be compacted as specified at the correct moisture and density.

Methods of traversing swampy areas generally consist of totally excavating the undesirable material and properly disposing of it, or providing a sufficient weight of embankment (surcharge) that will displace the swampy material when the depth of the swamp is too great to excavate. The soft ground may be bridged with an embankment composed of a wide bottom and very flat side slopes.

Swampy areas or soft areas are generally shown on the plans with the specific method of construction outlined in the special provisions; however, all low, poorly drained or swampy areas that do not show on the plans must be checked for their ability to support the planned embankment. Consult the Division Materails Supervisor to determine if questionable areas will have the strength to support the embankment.

D. Embankment At Structures

Different types of material are generally available on the project for structural backfill and the contract special provisions will usually contain a section which designates the type of material to be used for structural backfill. It is important that the contractor use selective practice in obtaining material for embankments at bridge ends, culverts and similar structures, even though special provisions may not designate the type of material to be used.

Piers, bents, and culvert structures have on occasion been pushed out of line or subjected to undue stresses because of improper backfilling practice. Backfill is to be compacted uniformily in layers brought up equally on all sides of the structure to reduce unequal earth pressures on the structure.

Rocks, stones, frozen material, stumps, limbs, and other organic materials are undesirable as structural backfill. Organic materials can rot away in time, leaving a hole which will promote water percolation and backfill settlement. Large rocks and stones placed adjacent to a structure from points of stress concentration and as such can exert excessive undesirable pressures on the structure. Any undesirable material should be removed and replaced with suitable material. Fine materials are most desirable.

Embankment and backfill near bridge bents, backwalls and other concrete structures could be placed in layers of 8" loose thickness and compacted within 10 feet of the structural support, by methods and equipment that will not distort, misalign, or otherwise damage the installation. In order to insure that the structure will not be damaged it is advisable to use hand operated mechanical tampers adjacent to the structure. Proper moisture content, as an aid in excavating correct density and uniform compaction must be observed when backfilling all structures. Moisture and density tests must be taken and recorded.

Compaction of the roadway embankment for the bridge approach fills and structural backfill operations around bents and abutments require coordination between the road contractor and the bridge contractor. Construction plans are usually definite in telling which contractor must construct the approach fill. Discussions of this subject should be started between the engineer and contractor involved at the Preconstruction Conference with future discussions as needed during the course of the work.

E. Compaction, Moisture and Density

A.A.S.H.O. T-99 method A or C is used as the density standard for compaction control. The results of in-place density tests are compared with the results from A.A.S.H.O. T-99. Then the percentage of compaction is determined. The majority of T-99 density tests results are obtained during preconstruction phases and made available to the Project Manager for control during construction of the roadway. A sufficient number of tests must be taken to truly represent the soils being excavated and compacted. If the tests taken during the preconstruction phases would truly represent all of the materials at any depth in any cut, the Project Manager would not need to perform other T-99 tests during the course of excavation and embankment construction. However, it is rarely true that preconstruction testing will be entirely representative of all material being used on that project. Therefore, the Project Manager and his staff must make frequent check tests and be sure that each soil type characteristic is represented by a T-99 density test. As an aid in identifying the various soil types to be compacted some samples of these soil types can be obtained, placed in jars and labeled.

In this way the texture, gradation, and color can readily be seen or felt to aid the inspector's judgment in correctly matching the T-99 test results with the proper in-place soil type. Exact identification or exactly representative samples are seldom possible to obtain, because the varying soils conditions and rock strata encountered are usually mixed by heavy construction equipment and when hauled to the embankment site are further intermingled. Recognition should be given to the many causes of variation in test results.

Soils containing a high percentage of rock do not allow meaningful compaction or density tests but still must be compacted or otherwise densified to make a sturdy, durable road bed. When meaningful test results cannot be obtained, explanations as to why the tests could not be made are to be entered on the compaction test report form along with explanatory comments that show how acceptance is being made. Other methods of acceptance, namely experience and judgment, must be employed by the inspector to determine when satisfactory compaction has been obtained in areas where the normal density requirements cannot be tested. In such areas compaction or density must be to the satisfaction of the engineer. Good rock embankment construction practice, the correct use of leveling equipment, good placing practice, checking for the correct lift thickness, and the correct number of phases with compaction equipment will help to assure adequate compaction.

Sometimes the first two or three layers placed, over acceptable but soft material, cannot be compacted to as high a density as the succeeding layers. The firmness of the underlying layer will definitely affect the compaction of any succeeding layer so this fact must be recognized and proper adjustments made so that densities obtained in material above soft areas will be acceptable. When proper densities cannot be obtained, the soft material must be removed and replaced with suitable material.

Silty soils are quite sensitive to small changes in moisture content. Since the range of moisture content in which compaction can be obtained is small, processing these silty soils to the proper moisture content is a problem. Processing equipment should be available and the correct moisture content determined by adding water in increments and processing thoroughly. Repeating this process as needed, will generally overcome the moisture problem for silty soils.

Soils with expansive characteristics occur frequently in Montana and are generally found in upper cretaceous and tertiary clay shales (according to our highway geologists). These expansive clay-shales are known by the more common names of Cody shale, Niobrara shale, Telegraph Creek shale, Bear Paw shale, (known in neighboring states as Pierre shale), and Hell Creek shale. Shales in the Fort Union formation can also be bad actors, especially the Lebo shale. Other shales exist that expand equivalently to those just mentioned.

Expansive shales in Montana have P.I.'s from 11-30, wet density's near 130 lbs. per cu. ft. and are classed from A6(8) through A-7-6(20). They are high in sodium content (in the form of sodium montmorillinite or Illite) and when mixed with several clays are frequently called bentonite. Probably the most important thing to remember when encountering expansive shales is to obtain help in solving the problems they will or are causing. A good deal of engineering information can be gained from "in place" tests made on undisturbed samples. The Geology Section from Helena performs such tests and should be contacted so they can schedule a trip to the project.

Soils with expansive characteristics do occur frequently in Montana, especially in areas where the Bearpaw shale or Niobrara shales occur. Expansive soils give the most trouble when their moisture content changes. Expansive soils that have been placed and compacted in a dry state will absorb considerable moisture during a wet season and if highly compacted these soils will swell extensively. Expansive soils must be treated or protected so that moisture content and density as compacted will not change significantly throughout the lift of the roadbed. These moisture and density factors are not always the optimum moisture content or the maximum density as determined from a study of the relationship between moisture content, unit weight and per cent expansion for that soil. The moisture content may need to be increased a few percentage points above optimum, providing that the unit weight obtained will be acceptable. Field control of the moisture when dealing with expansive soils is of the utmost importance, since, if these soils are compacted too dry, even though the maximum density is obtained, the expansion will increase considerably when moisture becomes available. Conversely, if these expansive soils are compacted too wet, an undesirable low unit weight will result, the soil will shrink during the dry period and then expand again during a wet season producing a bumpy surface.

Optimum moisture content ± percentage points is a needed specification requirement. This tight limitation was established especially for moisture control of clay and soils containing clay but is applicable for other soil types as well. The specification is written so the moisture content can be modified by the engineer "for conditions applicable to the character of the material being tested." This escape clause is necessary to allow from some of the exceptions that will occur. Some of these exceptions are:

1. Some projects have a grade line that just skims the natural ground. They are balanced earthwork jobs that have little volume per cut. On such jobs much of the topsoil has to be used in the grade and when this happens "optimum" moisture makes the grade too spongy and has to be decreased a few percentage points to get the job built. How much to decrease is to be determined by tests and observation.

2. Cut areas composed of clays and silts that become intermingled, then undistinguishable in the fill, make it almost impossible to determine the correct optimum to use. Optimum for clay is usually much higher than that for silt. Situations like this require the soil to be worked to thoroughly distribute the water. Observation and testing will aid judgment in selecting the proper moisture content.

3. Occasionally, a diatomaceous earth will be encountered. This is a siliceous material composed of or containing numerous skeletons of microscopic one-celled algae, called diatoms. Such a soil is very porus, fine structured and extremely difficult to work with as a road building material. Optimum moisture content, as such, hasn't much meaning in a diatomaceous earth, so the moisture content can be varied if this material is to be used at all.

4. Soil composed almost entirely of granular material does need water for proper compaction but the limit of ± 2 percentage points can be lessened, because these are non-swelling soils. However, the moisture content should not be reduced to less than 4 points below optimum.

Naturally any change from the ± 2% of optimum moisture must be documented by test results and a description of the reasons for the change must be placed on the test report.

RULE OF THUMB FOR OPTIMUM MOISTURE

The following method is a RULE OF THUMB for determining the approximate optimum moisture content for generally cohesive or plastic soils and is offered for your information. Naturally, this method is not a specification requirement and at no time shall it be used to replace the standard method of determining optimum moisture. It is just a guide to help inspect areas that are not tested.

> "Optimum moisture content may be approximated by rolling a soil sample into a ball about the size of a golf ball. The soils should be rolled as tight as possible. The ball should then be placed between the thumb and first two fingers of the hand, and pressure applied. If the ball more or less shatters into several fragments of rather uniform size, the soil is very close to optimum moisture. If the ball flattens or pancakes without breaking up, the soil is over optimum. If the ball "weeps" in the hand when held for a few minutes, it is also over optimum. If it is difficult to roll the soil into a ball or cannot be balled at all, it is under optimum".

41.06 Finishing and Cleanup

Numerous small details which are necessary to provide the project with a neat, finished appearance must be observed and inspection must be performed while the major work items of the contract are in progress. Since no contract item exists to reimburse the contractor for the work of finishing and cleaningup, it is necessary for inspectors to be thorough and observant in their duties. Efficient contractors finish and clean up during the work and thereby minimize delays in final completion.

Rounding and finishing of backslopes should be done as the cuts are brought down so that the material removed can be more easily disposed of with the equipment available at the time. Debris from clearing and grubbing operations should be cleaned up when the work is in progress and can be performed with the heavy equipment available. Many jobs will slow down or run into overtime in the final stages because the contractor neglected to clean up as his work progressed.

When backslope rounding is done after the heavy eequipment has moved off and the roadway is completely finished, delays and inefficiency will result because of the difficulty in gaining access to the backslopes and difficulty in disposing of the excess material. These operations should be performed early in the grading stage when these areas are easily accessible by equipment. Cleaning up as the work progresses should be encouraged to help prevent delays in contract completion.

The finished earthwork should have a pleasing contour and be reasonably smooth and presentable in all respects. A rounding effect at the top of cut slopes will help the appearance and reduce erosion. Standards have been established for rounding of cut slopes, but wherever excess excavation is available and conditions permit, a rounding out at the toe of fill slopes is desirable to reduce erosion and increase the stability of the embankment. The end of a ditch section in a cut slope should be flared away from the embankment to avoid an abrupt change in the slope at the intersection of the cut and fill areas and to provide better access for drainage water running from the cut section.

Dangerous or objectionable rock projections or partially imbedded rocks in the cut slope should be removed and the slope neatly dressed where possible. Economic considerations will usually make it impractical to trim rock slopes to the exact cross section but with judgment and the contractor's cooperation a reasonably neat and presentable contour can be obtained and hazardous loose rock can be removed.

All earth work should be constructed to reasonably neat and uniform lines where channel changes, roadway ditches, inlet and outlet channels, and other similar features exist. However, when channel changes are made for any of Montana's fishing streams, the banks should be made rugged and overhanging where possible. Rocks should be placed randomly throughout the channel and the general overall appearance should be just as if mother nature had placed the ripples and pools herself. The new channel should have the same length as the section of the stream that was eliminated.

Cleaning up the roadway will mean different things to different Project Managers unless general guidelines can be established. An engineer who is a perfectionist may require every pebble to be in an exact, precise location; or as the rough shod easy-going engineer, he may not even notice plugged culverts. A compromise is desired between these two extremes so the finished roadway will be neat and presentable when accepted.

Slope stakes, grading stakes, lath, stakes placed for guardrail, culverts, and other highway facilities whether it is placed by the contractor or engineer should be removed and disposed of. Debris is to be removed from storm drains, culverts, ditches, drop inlets, trash racks, and fences. Plastic covering for concrete structures should be disposed of as soon as it is removed and not allowed to be blown about the project.

Unneeded traffic control devices, barricades, flares, or other signs, should be removed and the site cleaned up. Old roads, detours, haul roads, pioneer roads, or similar features are to be obliterated and the area neatly dressed. Blotches of asphalt, tire marks, traffic strips not required, and similar disfigurations should be cleaned from exposed work. Rock slopes should be scaled to remove any loose rock. All ditch sections should be cleaned and their grade checked for drainage. Drainage areas may be checked by the use of a water truck to flush out culverts, check drop inlets, storm drains, and other surface drainage facilities.

Frequent inspection tours should be made by the Project Manager and a list made of the various finishing and cleanup needs as work progresses. These needs can then be pointed out from time to time easily and orderly planned in the contractors future operation. An engineer who waits until the contractor requests acceptance of the project, before pointing out the finishing and cleanup details that he is aware of, is not being helpful nor cooperative in the construction effort.

41.07 Maintenance of the Roadbed

The contractor is responsible for maintaining completed portions of the highway facility until formal acceptance, and for providing adequate protective measures for various portions of the work being installed or constructed.

The contractor should be made aware early in the project that he must maintain the roadway by taking preventive and protective measures and by taking corrective action when damages have occurred.

The roadway surface should be made free-draining by keeping the grade smooth and slightly higher in the center to provide a more rapid runoff of rain water. Drainage courses, ditches, and culverts should be kept open and free draining to prevent saturating the sub-grade or ponding water on adjacent land. Heavy rains or water that has ponded, saturating the sub-grade should be drained off and the sub-grade aerated before placing the next lifts of material.

The cost of such maintenance or repair work is the contractors obligation. Some contractors may expect payment for excavating and disposing of, and replacing unstable material with suitable material. When this practice is for the contractor's convenience, it may be permitted at no payment providing proper disposal is made and the suitable material does not reduce the available excavation to the point of overrunning the contract amounts, or depleting excavation in a balance or borrow area.

When exceptional conditions exist, beyond the control of the contractor, and the contractor has done his best to protect the facility yet damage occurred, the State may participate in repair costs but only after a complete investigation by higher authority.

The State does not intend to pay for corrective measures needed to repair, replace, or adjust damaged facilities when such damage could have been prevented or minimized by taking precautionary measures.

The Standard Specifications direct the contractor to do protective and maintenance work preparatory to a seasonal work suspension, make the road passable and open to traffic during the suspension by providing the temporary roadway detour or traffic guidance, then upon resumption of work must renew the roadway to its shape prior to the seasonal suspension. During the seasonal work suspension, the State is obligated to maintain traffic over the temporary route or line constructed or provided by the contractor.

Under some circumstances, special maintenance may be directed by the engineer for the benefit of the traveling public. The engineer will be the sole judge of what work will be classed as special maintenance and should confer with the Division Construction Supervisor and Construction Bureau prior to issuing written orders for special maintenance work. When special maintenance work is necessary, payment will be made for extra work on a force account basis or at agreed unit price or when contract items exist, payment for special maintenance work can be authorized by change order.

41.08 Records and Documentation

Documentation that roadway excavation and embankment quantities have been properly cross sectioned, measured and staked will occur in the cross section notes. Volume computations will be made by the Data Processing Section when these field notes are submitted. Refer to Chapter III, Section 30.07, for information on recording, checking and editing the notes prior to their submittal to the Construction Bureau Helena.

Minor shortages or overruns in the quantity of excavation needed to complete the road bed may occur from time to time and are normally expected in highway construction work. Major overruns or underruns in the excavation item may also occur but can usually be anticipated some time during the course of construction.

Large changes in quantities must have proper notes showing: The reasons for the change; Number of men working; Quantity of equipment being used; Location of the work; Weather conditions; Inspectors; Discussion with the contractor; Dates that the work was performed; and Unusual conditions surrounding any change in quantities. All of the above information is to be recorded in the project diary or the grade inspector's diary or both, each day, along with an estimate of the production rate for each day's operation.

Estimates of daily production rates, when the contractor encounters material that changes his operation, are necessary information that allows agreement to or denial of additional money claimed by the contractor.

The grade inspector is required to keep a daily diary of the grading operation, weather conditions, and other conditions affecting the grading work. This diary or notebook record is in addition to the project diary and should contain such information as:

1. Date, Weather, and Soil Conditions.

2. Information on the number of hours worked each day by the contractor's forces and equipment at various locations in the project. This information is not meant to duplicate similar information found in the project diary, but is a more detailed explanation of construction operations in specific work areas.

3. The record should include data on the work in progress, (whether in channels, dikes, rough grading, finish grading, removing material from borrow pits, or within balance limits).

4. Weather conditions or other conditions delaying prosecution of the work are also to be recorded. These may include such items as equipment breakdowns, lack of equipment, too much excavating equipment and not enough spreading and compacting equipment, soils that are extremely difficult to compact, load or haul, backslope or inslope instability, etc.

5. Enough records are to be kept describing the progress of the work to enable the Project Manager to prepare weekly progress reports and accurate progress estimates.

6. A well-prepared and maintained grading diary will provide supporting information and records necessary to help explain reports on sampling and testing and provide back-up information necessary to show that the contractor's equipment complies with the specification requirements.

During the grading phase of the work, the project diary kept by the Project Manager or the engineer in charge, will show all of the information necessary to reconstruct any particular days' grading operation. The project diary will be an overall description of each days grading operation and will be supplemented by the specific, detailed notations made in the grade inspector's diary. These two documents prepared by different individuals will contain sufficient information to support or deny any claims for overruns or underruns of the excavation, overhaul, water, rolling, or other items.

The grading inspector's duties consist of discussion with the contractor's representatives, observation of the work for specification compliance, discussion with the compaction tester about the equipment used, density being obtained, and characteristics of the material, or taking of density tests himself on small slow jobs, whereas, on high volume grading projects the grade inspector might be placed in charge of two or three compaction testers. Some of the more important details that a grade inspector should observe are:

1. Proper lift thickness for the type of material being placed.

2. Uniform mixing of water.

3. Use of the proper equipment for the particular type of soil being placed.

4. Moisture content at or near optimum or if soil characteristics prevent compaction at optimum moisture content adequate documentation to prove that optimum moisture was tried and the results were unsatisfactory.

Some soils have the plastic limit very near the optimum moisture content and may be extremely difficult to compact unless a lower water content is chosen.

5. The compacted density must be within the range allowed by specifications for the particular soil type being placed.

6. The contractor's equipment should be inspected to determine whether it is in proper mechanical condition and is otherwise suitable for the work.

7. Excavated materials must be inspected for their suitability in the embankment. Unsuitable material, if uncorrectable must be properly disposed of and the excavated area measured before backfilling with suitable material. If soils are deemed unsuitable because of excess moisture, they are to be dried until they are suitable. Every effort should be made by the contractor to use the materials encountered in the roadway excavation, so that unplanned surpluses do not occur and indescriminate wasting is avoided.

8. The constructed roadway must be maintained in a proper condition to allow easy traffic movements and to provide proper drainage. Maintenance can be done by smoothing and watering preparatory to the weekend or holiday traffic. Water for dust control should be spread as needed for maintenance of traffic over the main line P.T.W., detours, or in other areas where dust is a nuisance.

9. The grading inspector is in charge of the grading operation, but he shall check with the Project Manager to find the limits of his responsibility and authority in dealing with the contractor. He is to keep the Project Manager fully informed, both by a daily written record and verbal reports, of the job happenings, problems, discussion with the contractor and general prosecution of the work.

IV-42 Overhaul & Haul

42.00 References

Standard Specifications, Section 12

42.01 General

The well planned movement of material from a cut to fill facilitates construction, minimizes construction costs, and shows the construction engineer and contractor how much material is to be moved and where it is to be placed. The simplest form of planned movement of material consists of summing excavation and embankment quantities until points are reached where excavation quantities equal embankment quantities, adjusted of course to shrinkage or swell. These points, called balance points, must include all materials and requirements in addition to the actual roadway earth work. Balance points establish the limits between which no borrow or waste should be necessary.

Prior to January of 1968 a free haul limit of 1,000 feet was established by specifications, through which the contractor would receive no payment for hauling material. The concept of free haul and overhaul has its beginnings in early construction history where no payment would be allowed for moving materials within the reasonable hauling range ability of the equipment used. Then when it was necessary to haul material a greater distance, payment would be allowed and that greater distance would be called overhaul. Therefore, overhaul consists of hauling excavated material beyond or through the limits of free haul)one thousand feet) from the source of excavation (cut) to its resting place in the embankment area (fill). Prior to the elimination of free haul, payment for overhaul was made after the work was completed, based upon a mass diagram prepared from actual grading factors experienced. However, overhaul is not an item of work, instead the item of work is "Haul". Haul is computed the same as overhaul with a free haul distance equal to zero. Balance points are still important and should be maintained. If balance points are neglected by the Resident Engineer the total grading quantities may become unbalanced and necessitate an unplanned waste borrow situation which would be highly expensive and result in an unpleasant appearance. Balance points as indicated on the plans represent the most economical haul computed from theoretical swell or shrinkage factors.

Payment for haul will be made on the basis of the most economical route as indicated on the final mass diagram analysis even though the contractor does not follow the original mass diagram. The inspector must check the excavation and embankment quantities as the work proceeds to be sure that the planned shrinkage or swell factors used are matching the actual construction quantities. A substantial change in the shrinkage or swell factors indicate that a change in planned grade, ditch, or side slopes may be necessary to avoid large overruns or underruns in the final pay quantities.

Earth work quantities taken from channel changes, inlet and outlet ditches, trenches, stripped areas, or materials used for approaches, ditch blocks, dikes and similar features must be included in the final calculation of haul quantities.

42.02 Mass Diagram

The direct distribution of excavated material and the quantity of waste or borrow may be determined in advance by the use of a mass diagram. When the faul is long, it is frequently cheaper to obtain fill material from borrow pits rather than from roadway cut sections. When borrow material is obtained, the material from cut section is wasted rather than transporting it to distant fills. The economics of whether to balance a project or use a waste and borrow procedure are complex and are best solved by the use of a mass diagram. The mass diagram is a line set up on a rectangular coordinate system that indicates the relative quantities of cut and fill throughout the project. For the purposes of constructing or reviewing a mass diagram the cut lines are recorded as plus and fill as minus with the balance line as a reference. Cut and fill volumes placed on the mass diagram have been adjusted for swell or shrink and will form a continuous line crossing and recrossing the balance line from the start to the finish of a project.

42.03 Haul

Haul can be defined as transporting material from one site to another along a designated route, usually the shortest practical route between those two points. Transportation will include the number of miles moved, times the weight or the volume being moved and will result in a measurement of ton miles or cubic yard miles or fraction thereof. Haul is not to be confused with overhaul where overhaul deals with a mass volume computation through a free haul limit whereas haul is a straight computation of quantity times distance with no deduction being made for a free haul limitation.

Haul computations are made from the approximate center of volume of the excavation area to the approximate center of volume of the embankment area, along center line or a line parallel to the main roadway under construction. Any additional haul distance caused by the contractor following round about or unordered cross haul are not considered. No measurement of haul distance right or left of centerline will be made for the cut and fill material normally used in the roadway prism.

The distance materials are moved from borrow sites to the highway right-of-way will be measured along the shortest practical route from the approximate center volume of the pit to the point of entrance onto the project. From the point of entrance onto the project the distance will be measured along center line to the embankment site or disposal area. The haul distance will be the distance from the center of volume of the borrow pit to the center of volume of the embankment or disposal site.

Payment for haul can be made on excavated material or aggregates when so provided for in the individual contract but may also occur as the result of extra work deemed necessary to satisfactorily complete the highway.

42.04 Records

The quantity and type of records necessary to document payment for overhaul are necessarily included in cross sectional measurements and the subsequent volume computations made by the Data Processing Section. It is important that the inspector, through his daily diary entries, keep a reasonably accurate account of material moved within balance points or material disposed of or taken from a borrow area. Good records of the haul operations should include the direction of haul, the approximate quantity of material moved each day, any changes ordered by the engineer, and any undirected cross haul maneuvers performed by the contractor. The grading inspector's records should also include the amount of material hauled past the original balance points. Unless balance points are determined from field observation and the quantity of material moved past these balance points accurately determined, no accurate calculation of swell or shrinkage of the actual quantities can be determined.

IV-43 - Watering

43.00 References

Standard Specifications, Section 13

43.01 General

A contract item has been established for watering embankment or surface courses or both and consists generally of applying water as needed to obtain optimum moisture for embankments and applying the correct water content to obtain uniform moisture distribution while compacting the various aggregate surfacing courses. Water may also be used to alleviate the nuisance of dust occuring under mainline traffic and through detours or other areas as needed.

Water may be introduced into the embankment soil or it may be introduced into the excavation area as pre-wetting. Similarly water may be applied during the processing and mixing of aggregate surfaces on the roadway or it may be applied as pre-wetting over the aggregates as they are produced from the pit. Water is measured and paid for on the basis of a unit consisting of 1,000 gallons and called an M. Gallon. Measuring can be done by approved meters or by obtaining the capacity of a hauling unit, and counting the number of full measure loads placed over the roadway.

43.02 Inspection

All water-applying devices are to be inspected for their accuracy and ability to distribute the water uniformly. Water distributing truck tanks may be calibrated by weighing them empty and again when filled with water. The net weight divided by 8.33 is the tank capacity in gallons. Each truck tank is to be identified by number and the number and capacity of each tank recorded in the watering notebook.

Water meters may be calibrated by pumping water through the meter into a previously calibrated water truck or water tank and then checking the weight of water pumped against the gallons run through the meter. Measurement of water applied is generally more practical, economical, and accurate when using a meter rather than using tank measure. Water may be loaded into sprinkler trucks through an acceptable meter and a record then kept of the meter start and stop numbers.

Quantities of water may be wasted from time to time or for other reasons become ineligible for payment. Pre-wet excavation areas can become overwatered. Water may be used for the contractor's haul roads, or for a variety of other uses, that are ineligible for payment. The grade inspector must, therefore, be alert to assure that the water paid for is actually used in the embankment areas or incorporated into the aggregate surfacing.

43.03 Records

The grade inspector is to record, on a daily basis, the number and size of loads delivered to the project by each truck. If the water is being measured by an approved water meter, meter readings are to be taken at the beginning and ending of each day or shift or at frequent intervals to assure that water being paid for is actually being incorporated into the work.

Records are to be maintained of any calibration or meter tests performed, of water trucks numbers, and their capacity,of all water used on the job that is intended to be paid for, and the watering operation in general. These records would include various discussions or decisions or directions between the contractor and the engineer involving the usual course of a day's business or involving unusual circumstances.

The grade inspector is responsible for proper determination of the quantities of water being measured and paid for so each day's entry signed by him is verification that proper measurement and payment has taken place.

IV-44 ROADSIDE DEVELOPMENT

44.00 References

Standard Specifications: Section 17

44.01 General

The contours left by new grading can be more easily covered with vegetation when the slopes are made to conform with natural ground. Land forms adjacent to new highways are one of the most conspicuous and enduring features of that highway and should, where possible, present a neat appearance to the traveling public. Erosion at the junction of cut and fill sections and along backslopes should be minimized by proper grading, prior to beginning seeding and landscape activities.

Where top soil is to be stripped, stockpiled, and replaced over the completed slopes as a bed for seeding and planting, the stockpile sites should be determined at an early stage of the work. Consideration should be given to such factors as convenience of handling, keeping furrow ditches and drainage ways free, eliminating injury to trees or other adjacent vegetation, and cleaning up after construction.

The basic purpose of a seeding, landscaping, or top soil operation is to prevent or minimize erosion, prevent stream pollution, provide a pleasant appearance to the roadside, provide stabilization for the highway inslopes and backslopes, and help control the magnitude of erosion that does occur, thereby protecting adjacent properties.

Planting of interchange areas and adjacent highway backslopes is done to control weeds and erosion, to provide a screen, reduce headlight glare, absorb traffic noise and for the obvious reason of highway beauty. When the intended purpose of planting is kept in mind the size, shape, and plant characteristics can be more easily matched to the design intention. For instance, the radius covered by mature plants should be visualized so that locations are selected that will not create a hazard or necessitate excessive maintenance.

44.02 Topsoil

The slopes over which topsoil is to be placed should be completed to the planned grade and the surface left in a roughened condition. A better bond between the topsoil and the subsoil will occur if the surface is left in a rough condition also grass roots will penetrate easier.

Topsoil is to be obtained from under embankment areas or over cut areas and stockpiled in a convenient location adjacent to the area to be covered. Topsoil removed from the surface of borrow areas should be stockpiled adjacent to the pit area and segregated from stockpiles of overburden and other undesirable material. Topsoil obtained from an excessive depth may not contain the proper quantity of soil nutrients, therefore, care should be taken in excavating for topsoil so that a sufficient quantity and quality of good soil will be secured.

Normally, topsoil is spread on the completed cut and fill slopes by a dozer. To eliminate as much erosion as possible the dozer on the last complete coverage should operate on slopes 3 to 1 or steeper at an angle of 45 degrees or 90 degrees to the roadway, depending on the steepness of the slope. In this way the cleat marks left by the dozer will not be running in the same direction as the flow, which will decrease channeling down the slope. This will also reduce erosion and pollution of nearby streams. Topsoil is to be spread to a loose depth of 4 inches when sufficient quantities are available. If sufficient quantity is not available then it should be spread to a uniform depth throughout the project with the quantity available. After spreading all rocks, brush, roots and foreign matter should be removed. All clods and lumps should be broken up so that the topsoil is of a free uniform texture.

Precautions must be taken when topsoil is placed on areas of the sub-base so that drainage from the sub-base will not be blocked by the more impervious topsoil material.

It is important that freshly spread topsoil be seeded as soon as possible. Fresh topsoil is ripe for seeding and new seed growth will help retain the topsoil from erosion.

Measurement of and payment for topsoil will be in accordance with the Standard Specifications and Special Provisions. The Project Manager should keep in mind that topsoil obtained within the R/W will be measured in stockpiles prior to spreading it on the slopes. Topsoil that is furnished by the contractor from sources outside of the R/W will be measured by the C.Y. of loose material level with the box in the hauling vehicle at the point of placement on the project. Topsoil to be used for reclamation of State optioned borrow areas will be measured and paid for by the State. Measurement and payment for topsoil used for reclamation of other than State optioned sources will be the contractors concern.

44.03 Conditioning Seedbed Surface

An arbitrary quantity of Condition Seedbed Surface is generally set up on a project in the event the topsoil has been overgrown with weeds or if it has become too hard for the seed to penetrate. Conditioning of excessively tight soil will generally require the use of a disc or harrow. The topsoil should be loosened to a depth of two inches.

44.04 Seeding

The seed mixture or mixtures specified in the contract have been formulated of species suitable for growing in the soil type predominating and are essentially suitable for that location because of their hardiness or other adaptive characteristics. Other seeds may be substituted for those specified when the specified seeds are unobtainable as evidenced in writing and when permission has been requested and obtained from the Construction Bureau Helena. A change order is required for changes in seed species.

Seeding is to be accomplished between the dates of October 15 and April 30 in the eastern counties and from October 15 to May 20 in the western counties unless the particular contract has other dates or the dates are revised in writing. Spring occurs at a specified calendar date each year; however, the weather does not respect the calendar, being extremely cooperative one year and uncooperative the next. Seeding dates may be extended or revised depending on the growing conditions encountered each year and the recommendations of agricultural experts contacted by the Department of Highway officials. Extension of seeding dates will be granted only when general weather conditions throughout the State have delayed seeding of farm lands or local weather conditions have obviously delayed the seeding dates.

The desired goal of seeding is to provide a good stand of durable grasses. To help promote this goal, seed of good quality that meets Standard Specifications must be sampled and tested in advance of seeding and be planted in an environment capable of germinating and sustaining a hardy long-lasting stand of grass. Samples of seed taken by State forces are to be submitted to the testing laboratory in Helena which will then submit these samples to the agricultural offices in Bozeman, Montana for germination testing, and determination of noxious weed content. The total time of sampling, testing and reporting may be as great as six weeks depending on the type of seed and the time for germination. The contractor should be encouraged to have available all seed for testing two to three months before the anticipated seeding date. Seedbed preparation, seeding, fertilizing and methods used are important in obtaining a hardy stand of grass. Some methods work well at one time, but must be changed at other times. For instance, more consistent and satisfactory results are obtained by drilling seed than can be obtained from either hydroseeding or broadcasting.

Care should be taken in seed storage to assure that proper temperature is maintained and protection is provided against excess moisture, and rodents. Seed that is stored at temperatures above 85° F. will show a loss of germination whereas, colder temperatures do not appear to reduce seed germination characteristics.

Montana's weather east of the Divide provides a minimum of moisture for proper seed growth, so deep-rooted legumes such as alfalfa, and sweet clover which will survive periods of drought and will stabilize soils early are used. Legumes usually will require inoculation to promote growth and grow well when instructions for their use (included with the package) are followed. The inoculant is usually mixed in water and then sprinkled on the seed while the mixture is being stirred. Exposure to heat and sunlight must be avoided and the seed sown promptly after inoculation.

The seed is to be spread or distributed upon the prepared seedbed no longer than 48 hours after the seedbed has been conditioned. Seed is to be distributed by drill, broadcast seeding, or hydraulic seeding as requested in the plans. Broadcast seeding, accomplished by hand or mechanical means, is the least desirable method of seeding and should only be used to seed very small areas or areas that are very impractical to seed by the other previously described methods. The Project Manager must give his approval before broadcast seeding can be permitted. Very few men are skilled enough to broadcast seed by hand and obtain good results. Therefore, when broadcast seeding is used, it should be done in two directions at right angles to each other and when the wind is not blowing. Raking, when necessary, should be done so that seeding depth is preserved and an even pattern of seed distribution is retained. Rakes are to be operated back and forth rather than in one direction only. Cross raking may be necessary but final raking on slopes should be done on the contour.

Areas that are on a slope of 3 to 1 or flatter are to be seeded by drill. Those areas that are steeper than 3 to 1, inaccessible or too rocky or muddy may be seeded by hydraulic means.

The desirable planting depth, regardless of the method used in seeding, is approximately ½" below the ground surface.

Grain drills or seeders may be used to plant grass seed, but will require modification to provide the proper seed application rate. Rows are to be seeded no farther apart than 8 inches at right angles to the natural flow of water on the slopes.

Hydraulic seeding equipment is to be operated such that the seed or fertilizer mixture is applied uniformly to the seedbed surface from the start to the finish of each batch. These operations must be closely watched to insure uniform coverage and it may be necessary to set up several test sections to assure that the equipment is operating properly.

Mixtures of seeds including some that germinate and grow early, some that are medium growers and some that take a year or so to develop are used. These mixtures are desirable because of their growing sequence which is designed to provide enough early growth to hold soil in place while the slower sod forming grasses are getting started. Before mixing the separate packages of seeds, the Project Manager should:

1. Obtain the labeled rate of purity or germination for the seed. Retain the label from each lot of seed for future reference and if the seed purity is below the minimum specified, the seed should be rejected. If the germination is below the minimum specified, the contractor can use a larger quantity of seed to promote an acceptable growth.

2. Record the gross weight of each kind and lot of seed used and if the weight is not labeled, the seed should be weighed and the weight recorded.

3. Obtain a separate sample of each kind of grass or legume seed used or intended for use.

4. Determine the rate of mixing for the seed formula based on the labeled rates of purity and germination. For example, assume that four types of seed have been used and that seed No. 1 has a purity of 95% and a germination of 87%. Then multiply 95 times 87 to obtain 82.7% of live seed or 82.7 pounds of live seed for every hundred pounds of bulk seed furnished. Assume further that seed No. 1 is to be spread at 25 pounds of live seed for every acre covered. Then determine the gross quantity of seed No. 1 required to furnish 25 pounds of live seed. This quantity can be determined by direct proportion as follows: 100 pound bag times 25 pounds per acre divided by 82.7 pounds of live seed per bag equals 30.3 gross pounds of this particular lot of grass seed. This quantity will be required to furnish 25 pounds of pure live seed. Application rates can be similarly computed for the other seeds if the germination, purity and coverage are known.

The contractor may desire to increase the rate of any or all of the components of the seed mixture to offset a possible deficiency when the official germination analysis is received. Should any changes or increases in the mixing rates occur a record of such changes must be made.

Every effort should be made to obtain test results before the seed is planted, to verify certification of the labels on the seed bags.

44.05 Fertilizer and Mulch

Fertilizers are needed to improve the nitrogen, phosphorous or potassium deficiencies in roadside soils; they are obtained from commerical sources, and contain proportionate parts of nitrogen phosphorous or potassium, such as 16-20-0. This ratio indicates there are 16 pounds of nitrogen, 20 pounds of phosphorous and no potassium per 100 pound of fertilizer as the available active ingredients in the bulk fertilizer supplied. The need for fertilizer has been determined through soil testing and stipulations are carried in the special provisions of the contract.

The rate of fertilizer application is specified in the special provisions of the contract as an application of available ingredients. A quantity of bulk fertilizer will contain both inactive and active ingredients. The active, live ingredients are nitrogen, phosphorous, and potassium, and are also known as available ingredients. The available ingredients within a quantity of that bulk fertilizer are labeled as a percentage of the quantity of that bulk fertilizer. For example, if a 100 pound sack of bulk fertilizer contained a quantity of 16-20-0, 16% would be nitrogen, 20% would be phosphorous, and 0% would be potassium. The actual weights would be 16 pounds, 20 pounds, and 0 pounds, respectively. Similarly, a 200 pound sack would contain 32, 40 and 0 pounds or an 80 pound sack would contain 12.8, 16 and 0 pounds.

Mulch is placed over the seeded areato dissipate rain drops, shade the ground, conserve moisture, reduce erosion from surface water, and in this way aid in the establishment of a good stand of grass. Various materials such as stone chips, paper, wood fiber, or hay and straw have been used to advantage as mulching materials in various areas of the country. However, Montana has had as much success with hay and straw as other materials and hay or straw is more economical since it is quite readily available from local sources along or around most highways. Straw mulch must usually be stabilized and held in place and this has been accomplished successfully by mixing asphalt and straw together, then spreading this material over the seeded area with a blower. Approximate application rates are one and one-half ton of straw per acre bonded with approximately 300 gallons of asphalt emulsion per acre. The engineer must determine the proper rate to use and can be aided by the rule of thumb that about 25% of the ground should be showing through the straw when using the above rate. Higher rates of mulching tend to make the grasses spindly and lesser rates do not afford sufficient protection during germination and development. The vegetative mulch should be inspected for evidence of musty, moldy or rotten hay and freedom from noxious weeds, rocks, or roots. Mulch material that is excessively wet (more than 50% moisture) is unacceptable and a deduction will be made when moisture content is less than 50% but in excess of 15%. The moisture content may be determined by weighing one or two representative bales of hay or straw, drying, and then reweighing to determine the moisture lost.

Bituminous mulch, fabricated mulch, fabricated netting, and fiber glass are other mulch materials that may be specified for any contract. When the type of mulch specified is not available other types may be substituted on a change order basis with Construction Bureau approval.

44.06 Planting

Attractive trees and shrubs and pleasing ground forms, and the continuous well kept cover of turf are categories of landscape work that contribute to the pleasing appearance of a highway. Plantings along the highway are generally planned objectively and particular kinds of plants are chosen for their utility or appearance at strategic locations along the route. However, the engineer should use his vision and imagination, thinking in terms of mature plant growth when reviewing the plans and inspecting the planting area. Trees that are planted too close to the pavement or those which restrict sight distance can become hazards and should be removed.

There are many objective reasons for planting trees or shrubs. Planting can be done for erosion control, traffic guidance, screening particular features from the highway, screening for headlight glare or sound, and snowdrift control. The Project Manager should determine the intention for planting trees and shrubs as an aid to their proper inspection. The intentions of the plans should coincide with local conditions so that trees are in proper position relative to utility lines, intersections or scenic views. Planned locations should be scaled from the plans or the stated distance used, and staked out on the ground from centerline stationing or other known points. Staked locations must be approved and should be final so the contractor is not required to dig new holes or shift plants to satisfy the whims or arbitrary desires of the engineer.

A number of factors are involved in the re-establishment of living plants, some of which can be controlled and some which cannot be controlled. Therefore, it is quite important to carry out all operations which can be controlled by following accepted horticultural practices. Frequently the specified kind or sizes of plants are not available and adequate substitutions are needed. Permission to substitute should be requested by the contractor in writing through channels to the Construction Bureau. Approval, if granted, will also be submitted in writing. Such unfavorable planting conditions as frozen ground or dry growing conditions may mean that plants cannot maintain enough moisture to survive transplanting, even when watered. Do not permit bare roots to be exposed when temperature is below freezing, and do not heat frozen balls of earth to thaw them out.

Pits should be dug before the arrival of plants at the planting sites and if these pits constitute a hazard they should be backfilled temporarily with the material which will later be used in planting. The pits should be dug as specified in the plans. Then, to expedite setting and to insure the protection of large balls, a skidway may be dug into one side of the pit. Soil excavated from the plant pits that is acceptable may be used for other purposes, but if unacceptable should be removed from the site and properly disposed of by the contractor.

The planting schedule must be discussed with the contractor before any work is begun. Planting orders should be verified, availability of the planned stock should be assured or proper substitutions arranged for. Advance notice of plant deliveries must be given to the engineer from the contractor so unloaded plants can receive adequate inspection. Plants unloaded without inspection due to lack of advance notice may be considered unaceptable and the contractor informed, so that this practice will be discouraged. Trenches should be opened, pits dug, and all possible preparation made to avoid any delays in planting when the plants do arrive.

Balled and burlaped deciduous trees should be laid down and the tops supported wherever practical and the balls covered with wet burlap, straw or soil. Heeled in plants should be well watered.

Care in preparing the planting area, assuring that plants are alive and will continue growth after transplanting, proper watering, protection from the wind and weather damage, and reasonable care should assure a satisfactory planting project. Carefully inspect plants that have been container-grown. They may have been held in the container for such a long period of time that they are pot-bound, stunted, and generally not acceptable; or container grown plants may not have developed a sufficient root system to sustain growth after transplanting. Plants may have been handled and shipped improperly and thereby became damaged in such a way that they are not acceptable. Container-grown plants stored at the site of the work must be kept wet at all times. Trees are to be securely staked, tied, or guyed as soon as possible after planting to prevent damage from whipping in the wind. This planting work is often delayed, to the detriment of the tree. Care should be taken in driving stakes to avoid any damage to the roots and similarly ties should be made at the proper height to contain a major portion of the top growth.

Plants may have been injured or damaged sufficiently to cause replacement even though the plant is not dead. An excessive number of dead, broken, or marred limbs, is sufficient cause for rejection. Trees and shrubs that do not have enough live roots to sustain growth should also be rejected.

44.07 Planting Inspection

A. Storage

The contractor shall store the plants in an approved building or location. It is not necessary that the plant material be inspected before the actual planting, as they are the contractor's responsibility. The place and manner of storage is important. Proper storage and handling is considered a necessary part of normal horticultural practice.

The best storage is a refrigerated cooler where the humidity and temperature can be controlled. The temperature should range between 34° F. and 42° F. In cases where this is not possible, a suitable temporary storage area could be provided by a cool cave, basement, barn or shed. Other areas that could also be considered for a short period of time, would be a lathe house or the shaded northside of a building. In all cases of temporary storage, the bare root and balled and burlap stock shall be heeled in (the roots covered), with soil, sphagnum moss, sawdust or wood chips. The canned or potted stock need not be heeled in.

Improper storage which has caused plants to die or dry out and deteriorate shall be cause for rejecting plants. It is important to periodically check the condition of the plants while in storage. Experience has shown that some plants were allowed to dry out while in storage, but were watered just before delivery. Watering just before the delivery will only make dried plants appear strong and healthy. The effects of drying would not show immediately. Rather, there would be slow drying, discoloring and hardening of the branches from the tips downward to the roots or base of the paint. While in storage, all stock shall be watered every day. Roots must be completely covered with soil to prevent drying.

B. Handling & Planting Bare Root Stock

It must be understood that exposing the bare roots to the air, wind or heat even a few minutes may dry the roots enough to kill the plants. The roots of conifers or evergreens, exposed even a few seconds can kill large portions of the plant. Conifers and evergreens have a very fine fibrous root system that cannot stand exposure.

After the plants are delivered to the project for planting, quickly transfer them to tanks or barrels of water. Keep the roots submerged. When the plants are removed from the tanks for planting, place them in buckets of water while taking them to the planting holes. This is good horticulture practice. It is even better practice to fill the buckets with a mud slurry. Then, as the plants are removed from the slurry, the roots will be covered with a mud film which will protect them during the final planting procedures.

The planting holes must be large enough to provide approximately 6 inches of clearance between the sides of the hole and the spread of the roots. Approximately 8 inches is needed between the bottom of the hole and the lower tips of the root branches. The roots are to be spread naturally. Do not crowd roots together in order to fit a small hole.

The plant is to be suspended in place in the center of the hole. (Suspension can be by hand.) Then pour the backfill material, soil and peat over and around the roots, compacting it firmly. Stepping on the soil will compact it satisfactorily. The compacted soil should reach about 3 inches higher on the plant than the soil level it had while growing in the nursery. This added soil height will allow for settling of the backfill material.

C. Handling & Planting Canned or Balled & Burlap Stock

Container grown stock and balled stock shall always be picked up and handled by grasping the container or ball of earth. Never carry plants by grasping the stem or upper crown. Any plants which are carried or picked up in this manner should be rejected because their fine roots will have been severed.

The planting holes for balled or container stock must be large enough to allow about 8 inches of clearance on the sides and 8 to 10 inches at the bottom of the hole. Remove the twine and burlap from around the stem of the plant on balled stock, immediately after planting. If the container grown stock is supplied in peat pots, they can be planted in the pots. The peat pots will soon decompose allowing the roots to grow through the pots.

If the containers are metal cans, three or four cuts should be made down the side of the can. Then bend the sides of the can and spread it out flat. The plant can then be easily lifted from the container by the roots and soil ball, and set into the planting hole. The backfill soil is to be placed around the roots and compacted in the same manner as for bare root plants.

D. Pruning

All deciduous plants should be pruned immediately after planting. Inspectors must insist that each deciduous plant be pruned when it is planted. Do not delay pruning until the entire project is complete. The survival rate of planted, unpruned plants is very low comparable to pruned plants. Pruning gets the crown or top of the plant in balance with the root system as soon as possible. A good rule of thumb is: cut the branches back until about ¼ to 1/3 of the plant has been pruned off.

E. Inspection At Time of Planting

1. The roots of all bare root stock shall be soft, pliable and undamaged or unbroken.
2. Plants which are torn or broken at the crotch of either the branches or roots should be rejected.
3. Plants which are left laying with the roots exposed should be rejected.
4. Canned or balled stock shall be handled by the container or earth ball only.
5. The slightest indication of handling these plants by the tops or dropping or throwing them shall be cause for rejection.

44.08 Establishment Periods

On many projects a plant establishment period is specified to assure a satisfactory plant growth is attained. If the original plantings are completed during the spring planting period the establishment period ends at the final inspection on May 1 of the following calendar year or immediately thereafter. For plantings completed prior to November 1 the establishment period ends on September 1 of the following year.

During the establishment period, care and maintenance of the plants are the responsibility of the contractor.

A final inspection of all plant material is made at the end of the plant establishment period. All plants in a healthy condition at the inspection are to be accepted and all plants found to be dead or dying are to be replaced.

On many projects all items of work that have been completed with only the final inspection at the end of the plant establishment period remaining. In instances such as this the Certificate of Completion shall be issued when all work has been completed with a special note added referring to the plant establishment period. For an example of this see Figure II-6.

44.09 Records

A general inspection is usually made of plant stock at the nursery or source of supply, and the various items may receive prior acceptance before their arrival on the job. Regardless of whether plants have received prior acceptance or not, the inspector must examine each shipment of plant stock noting the condition of the plants, and compliance with specifications, or any accompanying certificates. Plants that are not satisfactory should be rejected. Similarly, seeds, fertilizer, mulch, and asphalt to be used in grass planting or grass seeding operations.

The inspector must determine if the work complies with the specification requirements. This will require a thorough review of the contract special provisions to assure that planting or seeding operations are done in conformance with the contract requirements. Records are to be kept of all operations and inspection of these operations on a day-to-day basis both in a diary and in looseleaf notebooks. Diary notations should conform to good diary keeping practice as noted in various other portions of this manual. The notebook entries should show the various contract items, date inspected, dates installed, inspector's name, weather data, sizes of nursery stock and quantity of material planted, sowed or used, as well as other information sufficient to prove that proper equipment was allowed for the contract items installed according to the specification requirements.

Seeding, mulching, and fertilizing operations may require various test sections to calibrate the application equipment and make sure that material is applied uniformly and at the correct rate over the area designated. Sketches or other notations are to be made in the notebook stating the date, type of test section, and results obtained.

It is advantageous that each item for payment (seed, fertlizer, mulch, asphalt, and each kind and size of plant shown on the contract) be set up on a separate page or section in the notebook, allowing sufficient pages for future entries under that item. Each item should be recorded in a manner that will allow an easy summary to be made for the monthly progress and final estimate. Records must be set up so that at the end of each day the number of units satisfactorily planted or seeded can be entered with the date, inspector's signature, and pertinent remarks. If one or more units has become unsatisfactory, these may be entered in red and the necessary explanation recorded.

A separate file or recording system should be established to contain records of the material tested both on the project and testing performed at the material source. Records of prior approval, labels from fertilizer, mulch, and grass shipments should be retained as well as manufacturer's or supplier's proof that trees and shrubs meet the specification requirement for species, size, and hardiness for that area.

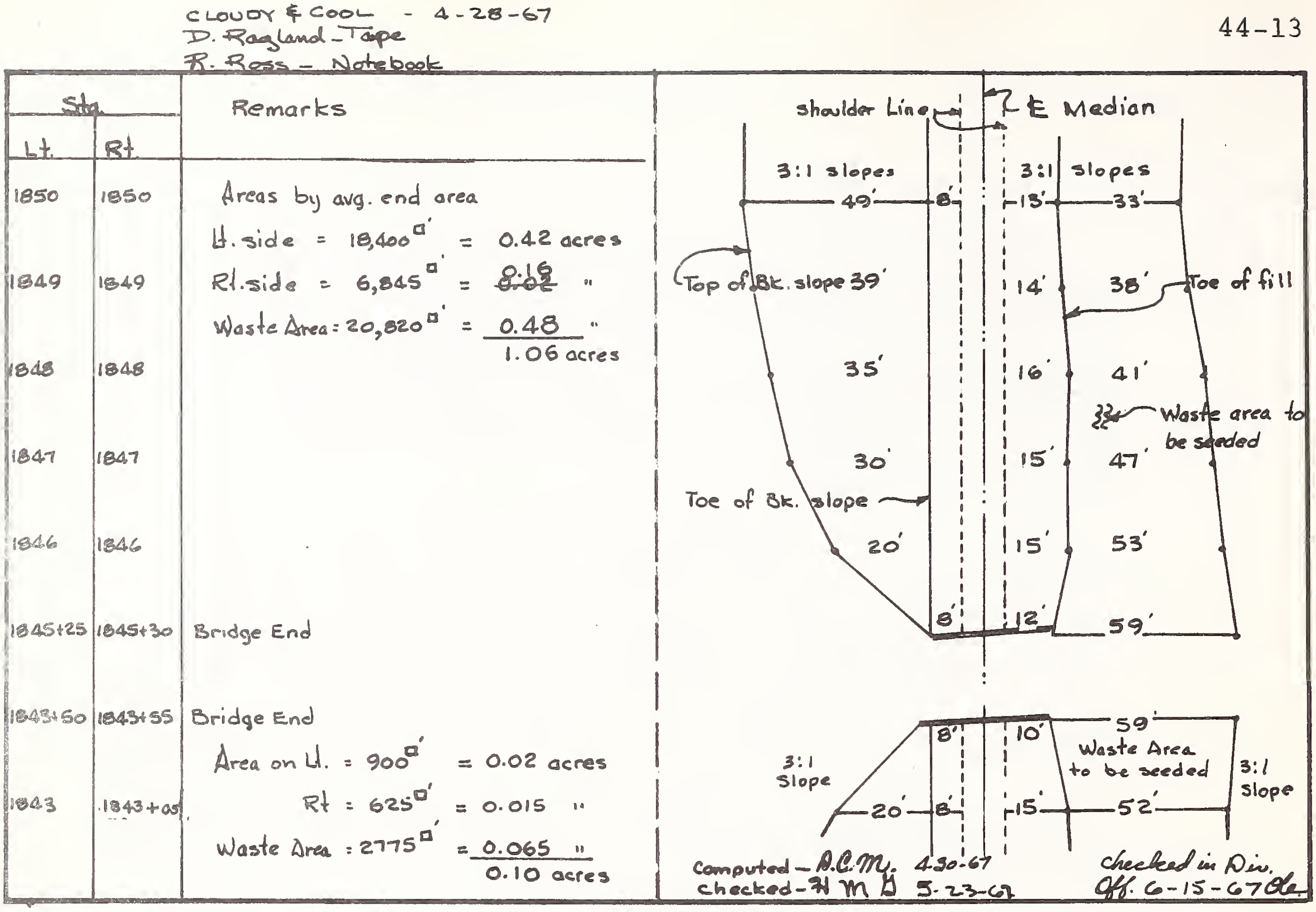
Figures IV-3 and IV-4 are examples of pages taken from a typical notebook where seeding was done by drilling and is shown as a guide only. Each Project Manager should be sure that his notekeeping method will provide the needed documentation for that particular contract and since each seeding, planting, or beautification project may differ considerably in their record-keeping requirements, his previous system may need revision to fit today's requirements.

A. Seeding Notes

Prior to actual seeding operation it is necessary to determine what sections of the roadway are to be seeded, perform measurements and record the area in square feet for later conversion to acres. The seeding notebook should be divided into various sections for seed, mulch, fertilizer, seedbed preparation, etc., such that records and documentation for each contract pay item can be easily retraced.

B. Planting Notes

Contracts for planting of trees and shrubs may be let as a lump sum and included in other items of work or each species of plant may be let as a separate item (each) within a beautification, screening, or comfort station contract. Proper documentation requires that each species of tree has records showing the size, species, planting location, conditions of acceptance, and other factors showing specifications were complied with. The weather, date of planting, date of inspection, inspector's initials or signature, and records of personnel computing, recording, and checking computations must be shown as a matter of good record-keeping practice.



CLOUDY & COOL - 4-28-67
D. Ragland - Tape
R. Ross - Notebook

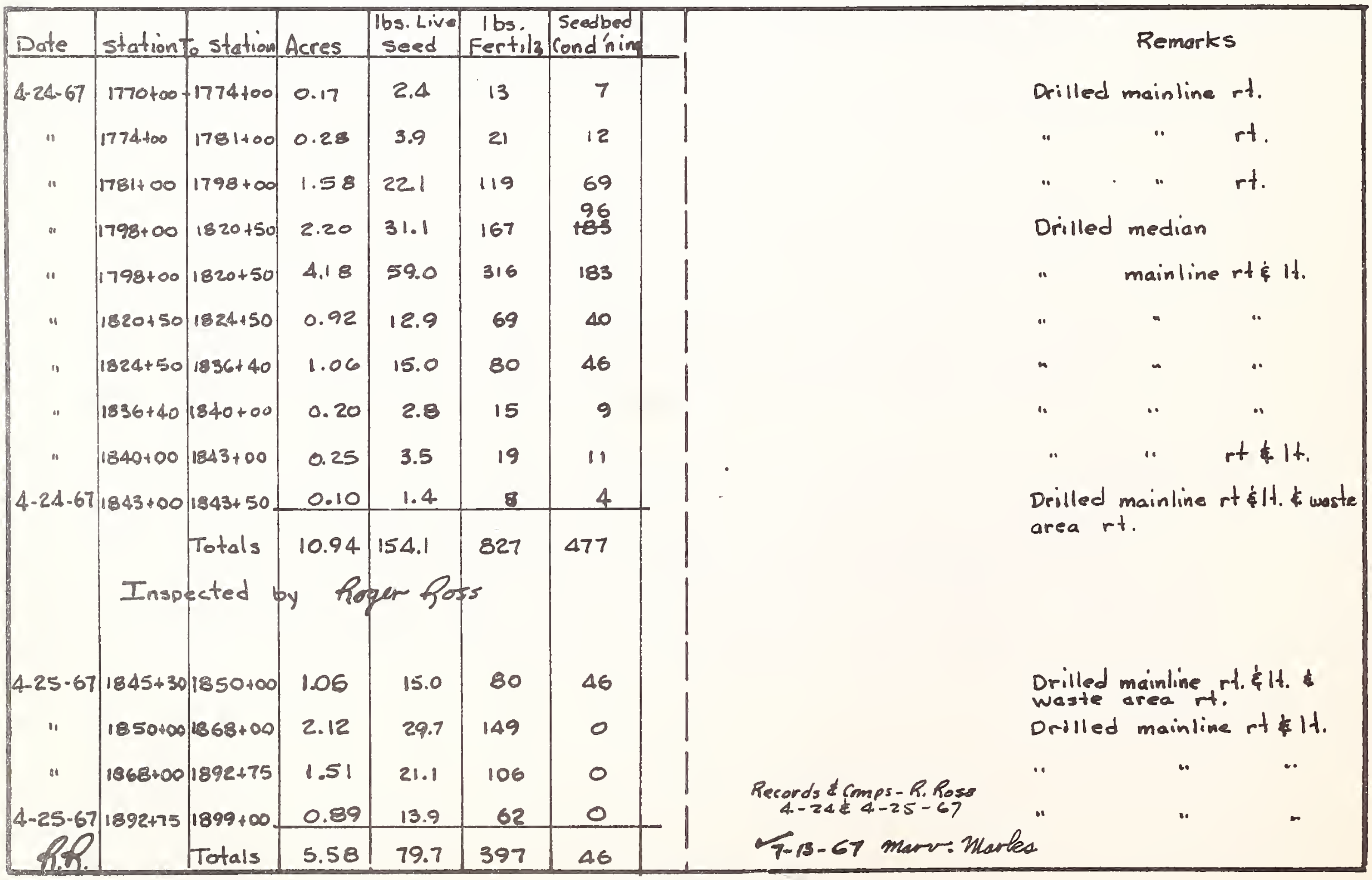
Sta. Lt.	Sta. Rt.	Remarks
1850	1850	Areas by avg. end area
		Lt. side = 18,400□' = 0.42 acres
1849	1849	Rt. side = 6,845□' = ~~0.02~~ 0.16 "
		Waste Area: 20,820□' = 0.48 "
		1.06 acres
1848	1848	
1847	1847	
1846	1846	
1845+25	1845+30	Bridge End
1843+50	1843+55	Bridge End
		Area on Lt. = 900□' = 0.02 acres
1843	1843+05	Rt = 625□' = 0.015 "
		Waste Area: 2775□' = 0.065 "
		0.10 acres

Shoulder Line
℄ Median
3:1 slopes
3:1 slopes
49'
8'
13'
33'
Top of Bk. slope 39'
14'
38'
Toe of fill
35'
16'
41'
Waste area to be seeded
30'
15'
47'
Toe of Bk. slope
20'
15'
53'
8'
12'
59'
59'
8'
10'
Waste Area to be seeded
3:1 Slope
3:1 Slope
20'
8'
15'
52'

Computed – A.C.M. 4-30-67
Checked – H M B 5-23-67

Checked in Div. Off. 6-15-67

FIGURE IV-3



Date	Station	To Station	Acres	lbs. Live Seed	lbs. Fertilz	Seedbed Cond'ning		Remarks
4-24-67	1770+00	1774+00	0.17	2.4	13	7		Drilled mainline rt.
"	1774+00	1781+00	0.28	3.9	21	12		" " rt.
"	1781+00	1798+00	1.58	22.1	119	69		" " rt.
"	1798+00	1820+50	2.20	31.1	167	~~183~~ 96		Drilled median
"	1798+00	1820+50	4.18	59.0	316	183		" mainline rt & lt.
"	1820+50	1824+50	0.92	12.9	69	40		" " "
"	1824+50	1836+40	1.06	15.0	80	46		" " "
"	1836+40	1840+00	0.20	2.8	15	9		" " "
"	1840+00	1843+00	0.25	3.5	19	11		" " rt & lt.
4-24-67	1843+00	1843+50	0.10	1.4	8	4		Drilled mainline rt & lt. & waste area rt.
		Totals	10.94	154.1	827	477		
	Inspected by Roger Ross							
4-25-67	1845+30	1850+00	1.06	15.0	80	46		Drilled mainline rt. & lt. & waste area rt.
"	1850+00	1868+00	2.12	29.7	149	0		Drilled mainline rt & lt.
"	1868+00	1892+75	1.51	21.1	106	0		" " "
4-25-67	1892+75	1899+00	0.89	13.9	62	0		" " "
R.R.		Totals	5.58	79.7	397	46		

Records & Cmps - R. Ross
4-24 & 4-25-67

✓7-13-67 Marv: Marks

FIGURE IV-4

Rev. 4-1-69
Rev. 5-I-73

IV-45 AGGREGATE PRODUCTION & SURFACING

45.00 References

Standard Specifications: Section 20 and 26 and Section M-100

Construction Manual: Sections II-13 and II-21

45.01 General

The structural section composed of surfacing extends from the top of the sub-grade to the top of the finished pavement and is composed of layered design, with the larger aggregate comprising the lower strata and finer aggregate in the upper layers. Design methods are used, based on the ability of various types and gradations of aggregate to support wheel loads of different intensity and the average daily traffic count. Information gained from the ASSHO road test combined with past practice and the experience of other states and agencies have allowed development of design criteria which provides satisfactory roads. Although surfacing thickness has been set in the design stage prior to construction, the Project Manager is to be familiar with the process of determining surfacing thickness in case it is necessary to revise the depth or section because of a change in type, quantity, or characteristics of the material encountered, changes in the grade, or for other reasons. If conditions arise that require a redesign in the surfacing thickness, the Project Manager should present his information to the Division Construction Supervisor and then request form approval through the Construction Bureau in the form of a change order after verbal discussion thereof.

The Project Manager is responsible for enforcement of all specifications including site acquisition, reclamation, stripping, crushing, screening, hauling, placing, finishing and cleanup procedures, as well as the specifications governing gradation, quality and quantity. Inspectors assigned to cover various operations must be equipped with the proper tools to test material and inspect plant equipment and facilities. Sampling devices or access for obtaining proper samples must be provided and continuous access assured before any production can be allowed.

Each inspector is to be familiar with the methods and procedures involved in crushing, screening, hauling, and placement so that the operation he is inspecting can be intelligently appraised and any discrepancies cleared up before they become serious

The Project Manager or his authorized representative for each phase of the work should inform the contractor of test results at frequent intervals to allow any needed adjustment to be made in time. The contractor is to be informed immediately when the produced material does not meet the requirements of the specifications, so that corrections can be made. Records must be kept of daily events, test results, troubles and corrective action that has been taken, or refusal to take corrective measures.

The engineer should get the description of the material source location as soon as the source is known. All other items connected with the removal of the material from the area must also be appraised such as location, reclamation requirements, haul roads, load limits and requirements of local state, or federal authorities pertaining to their roads. Any utilities in the area must be reviewed for proper clearance and protection and location with regard to safety. Poles are not to be placed where an out of control vehicle would strike them. Crops in the immediate area must not be damaged and provisions are to be made to prevent straying of livestock into the work area. The terms of agreement between the landowner, contractor or state must be known or made known to each party and the agreement then adhered to. For instance, the degree of slope on the sides of the pit must meet landowner approval as well as other contract requirements after material is removed, therefore, the contractor must be told of these requirements before the job begins.

Complete conformity with the Montana Standard Specifications, dealing with Reclamation Requirements on local material sources and with any revisions or additions thereto, should be ridigly enforced. This requires conformance with the requirements of the Montana Open Cut or Strip Mined Reclamation Act (Chapter 224, Session Laws of 1971). The article also requires that the contractor submit a reclamation plan to, and receive approval of the plan from, the Montana Department of Highways prior to commencing any operations in the source area. Reclamation requirements are outlined in Section II-21.

Before extensive development begins, the engineer must make a thorough review of the pit area to find out whether the quality and quantity of material in existance will truly satisfy the contract requirements. When deficiencies in either quality or quantity exist the contractor must be told of these facts so other arrangements can be made if necessary. When the material in the pit source differs in quality or quantity from that shown on the report of available surfacing, exploration or sample test results, this information is to be immediately given to the Division Construction Supervisor and prompt action taken to determine the extent of deficiency and need for acquiring other surface sources. If the pit source is a site that proves unacceptable, the State must provide another source at no cost.

Aggregate base courses are designed as the intermediate layer between the sub-grade and the pavement surface. They transmit traffic loads through the surface courses to the sub-grade. Wheel loads are spread out on an approximate 45° angle from the surface course through the aggregate base course and sub-grade into the natural ground. The wheel loads are then distributed as they are transmitted to each layer of the roadbed with the stresses concentrated at the surface and becoming less concentrated with depth below the surface. This fundamental design concept generally explains why high quality materials are needed at the surface and progressively poorer quality materials can be used from the surface downward. The material used in the aggregate base courses must have the right gradation, be thoroughly compacted and remain solidly in place in order to support the wheel loads. Part of the control process, to assure that the aggregate produced will be uniform and capable of supporting applied stresses, is inspection of the production operations.

45.02 Crushing and Screening

When material is being produced and temporarily stockpiled for future use it is an accepted practice to test the aggregates during the production phase for the convenience of the contractor and for our own information. Acceptance of stockpiled material is based on samples and tests made at the time the material is removed from the stockpile. These materials produced for immediate incorporation into the roadway are accepted on progress tests that are performed at the plant site. All samples may be taken at the point of production but when testing facilities are not capable of making all necessary tests, samples can be sent to the division laboratory for testing. It is preferred that field laboratories be equipped so all testing can be performed at the plant site. When acceptable and borderline materials occur at different levels within a pit or a material source, these materials can be more efficiently used by proper blending or mixing before or while they are fed into the crushing or screening unit. Remember what goes into a crusher will come out of the crusher either as acceptable material or unacceptable material, so when most of the input is undesirable it is expected that most of the output will be undesirable unless corrections are made.

The contractor may claim that crushing and production of aggregates intended for the hot mix is under his control and jurisdiction, not the States, and that the State cannot require him to produce material within the specifications. The contractor is technically correct in believing that State testing is done for information rather than for direct control purposes, because, the State is not purchasing the material at this stage of production and it is not the final product. However, when informational testing is performed and the produced material is borderline or out of specifications, the contractor must be immediately informed, preferrably in writing. Then every effort should be made by State personnel, to have the contractor correct his process. Corrections made during crushing are usually easier and less costly to a contractor than corrective actions taken later at the hot plant. It is wise for the Project Manager to have adequate records of proceedings and discussions about the out of specification product when it was produced. Records will show that the contractor made his choice of production procedure and that any necessary corrective measures would also be his choice.

Inspectors must be properly equipped to perform sieve analysis for gradation, examine the particles for per cent of fractured faces, determine the moisture content, and test for presence of deleterious matter. Other testing functions may be required occasionally but these are the most common tests performed in the field. Inspectors must have adequate space in which to work. The space is either furnished by the State or provided by the contractor. In no case shall production and acceptance of materials occur until adequate testing facilities are available and a sufficient number of trained personnel are on hand to control the product.

The crushing and screening operation is similar to an assembly line where a product is constantly produced and expected to be within certain pre-set limits or tolerances. The limits or tolerances for aggregate production are found in the Standard Specifications, and consist of gradation, wear, liquid limit, plasticity index, volume swell or other quality requirements.

The test results of each aggregate sample are accurate for material in that sample only, but in some way must represent all of the material being produced. Test results are true only for the sample itself but can be made to cover all of the material produced between samples by the use of inspection, observation, and common sense. The inspector can observe each sample as it is taken and during sieving to look for the percent fracture, dirtiness, or cleanliness, and the variety of sizes present. He can then mentally compare this information with material he sees being produced. An observant inspector is also a good listener. He hears production noises when good material is being produced, remembers these sounds then makes a comparison with the noises happening on his inspection rounds. Common sense tells him that sand should make less noise or different noise than 10" rock when it is passing through a crusher, and a good experience in listening will bear this out. Therefore, it is helpful for an alert inspector to know where sand and rock pockets are in the gravel pit, so he can be on guard both by eye and ear, and know when these materials are encountered. Then test results of production samples can be made to represent all of the material being produced.

Separation of fines from coarse fractions of aggregate may occur at any time during production or placing and is detrimental to a good product. Separation produces a non-uniform product with varying density and durability when placed. When material is separated, the fine fraction by itself will not meet specifications nor will the coarse fraction by itself. Both portions must be combined in the proper amounts to meet specifications. Separation of the fine from the coarse fraction is called segregation and is to be prevented. Segregation of material may occur when conveyor belts dump directly into stockpiles, or discharge material into trucks or dump trucks, but can be minimized by proper handling and use of corrective devices such as baffels, mixing chutes, or rock ladders. The contractor should not be permitted to continue production methods when his methods tend to cause segregation.

45.03 Stockpiling

When the contractor is producing and stockpiling aggregate for future use as plant mix bituminous surfacing, he may claim the material going into the stockpile and the method of stockpiling is his responsibility and the State has no jurisdiction over his working methods, because that is not a final product and they are not purchasing the material in the stockpile. Although this may be true, every effort should be made to have the stockpile built with a minimum of segregation, especially when radial stackers are used. When radial stackers are used it is common practice to elevate the conveyor to its maximum height and leave the stacker at the same location until the aggregate piles up to the bottom of the conveyor, leaving a high cone shaped pile, which increases segregation. This can be improved by moving the radial stacker more frequently, resulting in smaller better mixed piles. Stockpiling by end-dumping or dozing the material over the edge also causes segregation. When the material is purchased in the stockpile the stockpile must be constructed in accordance with the provisions of the Standard Specifications or special provisions and in accordance with good practice.

The area upon which the stockpile is to be placed must be cleaned of all vegetation and loose material. This will minimize wasting material, and help prevent contamination when the material is removed from the stockpile. Maintenance stockpile locations must be approved by the engineer, but it's the contractor's responsibility to prepare the necessary area to stockpile sufficient material to complete the work.

It is common practice to make separate stockpiles for each different surfacing stage. Each stockpile must be separated an adequate distance from other stockpiles to prevent intermingling of one material with the other.

Stockpiles are most frequently constructed by trucks and leveling equipment. The stockpile should not be allowed to become contaminated with mud or other material tracked in by trucks or dozers. Contamination can be minimized if the surrounding ground or haul roads are hard-surfaced or have gravel placed on them as a means of keeping the tires clean. Stockpiles constructed by truck should be built up in layers, the layers not to exceed approximately 4 feet in thickness. The material should be dumped in its final resting position and maneuvered as little as possible since maneuvering and spreading dumped material will tend to segregate it. Each layer should be kept within the limits of the layer on which it is placed as an aid in reducing segregation. A dozer is usually used to level the top of each layer after it is completed and before the next layer is placed. This practice tends to segregate material but may be permitted when the dozer is limited to the minimum amount of work required to level the top layer.

Leveling done in this manner can result in serious degradation of the material (breaking the rocks), especially if the stones are rather soft and will break under the force of the cat tracks. When it is known that the aggregate is extremely soft, the use of dozers on the pile should be prohibited and the pile leveled by some other method that will eliminate degradation of the product.

Gravel stockpiling work is often done during the night hours and at this time inspectors must be especially alert to be sure that all phases of the work are being carried out in accordance with the specifications. Proper inspecting and testing work is difficult to accomplish with precision during night hours even when adequate light is provided. Adequate light must be provided to illuminate the crushing site, stockpile area, inside of testing trailers, testing equipment, especially the location from which samples are obtained and other points along the production line requiring inspection. How much light to provide is up to the Project Manager. Enough light is needed to do safe work and do good inspection of all work.

45.04 Scales

A. Belt Scales

Scales used to measure aggregate will meet the requirements of Article 20.03 (F) of the Standard Specifications. Platform scales will usually be used, however, the following provisions have been established which allow the acceptance of belt scales on a project by project basis.

1. Belt scales are acceptable for untreated materials only.

2. Scales with documented prototype approval from the National Bureau of Standards, and acceptance by the Construction Bureau can be used independently for documenting pay quantities subject to compliance with the requirements below and all other applicable requirements of the Standard Specifications.

(a) A manufacturers representative will make the initial calibration on the first project in each Division to instruct project and Division lab personnel on these procedures for checking the calibration.

(b) The scale calibration will be checked once daily and more often if requested by the engineer.

(c) The scale may be cross checked with a platform scale occasionally, provided that a commercially acceptable platform scale is within a reasonable distance from the materials site.

(d) The contractor will provide an automatic predetermining load mechanism which will be set and locked by the engineer prior to delivery of any materials to the roadway.

3. Scales without prototype approval, etc., must have a certified platform scale within access of the project and crosschecks must be made at reasonable intervals to document the accuracy of the scales. (Frequent checks should be made when beginning operations with less frequent checks after consistent accuracy).

Under the above conditions, belt scales will enable us to eliminate the present requirement for a state scaleman at the materials source as well as the tickets he presently issues. The roadman will keep an account (punch cards are acceptable) of the number of loads delivered to the project and crosscheck his figures with those indicated on the scale totalizer at the end of each shift.

According to available information there is no automatic printing device, for use with belt scales, which is capable of documenting loads to one-tenth of a ton. The availability of such a device, which will not limit the production of a plant because of inability to record at normal plant production speeds, will allow acceptance of presently unacceptable varying loads.

B. Scale Inspection

It is recommended that all Department of Highways personnel who have been deputized as Deputies of the State Sealer of Weights and Measures refrain from inspecting or testing scales for commercial firms or individuals engaged in selling or offering for scale commodities to the general public and he shall confine his activities only to those contractors engaged on Federal and/or State Aid Highway Projects under the jurisdiction of the Department of Highways, unless specifically directed otherwise and in writing by the Weights and Measures Division of the Department of Agriculture of the State of Montana.

Included here are the latest Instructions for Testing and Inspecting Motor Truck Scales as issued by the Weights and Measures Division of the Department of Agriculture of the State of Montana.

All lever bearings shall be examined to see if they are in place.

All connections shall be plumb, especially the rod from the scale up to the beam.

Beams should be level when resting in the middle of the trig loop, as this is where the lock is to hold the beam down.

Scale frame and levels should be level both lengthwise and crosswise.

Platform should be free with at least 1/2 inch clearance on each end, and should be covered with belting, providing the belting is resting only on the side it is fastened down on when the scale is being tested.

After the test is completed, belting can be let down to rest on the platform and frame.

To test a motor track scale with 1,000 pounds of test weights, place the total weights directly over each bearing and the center of the platform, and the readings should be the same with only 1,000 pounds of test weight.

The weights should be placed on a two section scale in five positions, a three section scale in seven positions and a four section scale would be nine positions.

Check the balance after the weights are removed to see if there is no change in the scale balance.

A truck loaded to the maximum amount that will be weighed over the scale should be driven on the platform, first, in one direction and then be weighed and recorded, and then turned around and driven on the other way.

Each end should weigh nearly the same.

Leave the truck on the scale with the truck weights recorded.

Next add the 1,000 pounds of test weights, equally divided on each side of the platform, the total weight should only increase to the amount of the test weights applied. The scale should be accurate to one half of one percent at any weight.

The error should never be more than one of the minimum beam graduations.

The break of the beam or the (S R) tolerance is not to exceed one of the minimum beam graduations, when first test is made with the total maximum load on the scale platform.

The scale should be kept balanced at all times when in use, also the gravel should be kept from touching the levers, as this will cause an error in the weighing.

If there are any other questions regarding the testing of scales please feel free to contact the Weights and Measures Division of the Department of Agriculture of the State of Montana.

45.05 Spreading and Compaction

A material of good quality can be placed haphazardly undoing all previous worthwhile efforts. Segregation must be controlled or prevented in the construction process or, corrected by processing the aggregate before acceptance and payment is made. When segregation is suspected, confirm your suspicions by tests of material taken from the roadway. Remember, just because tests at the crusher showed satisfactory results, it doesn't mean that aggregates will remain within these correct limits through placement on the roadway. Processing aggregates on the roadway must be done when needed to correct segregation.

The sub-grade must be in acceptable condition and have no uncorrectable soft spots before any aggregate can be placed or laid. The roadbed surface is to be within tolerances for smoothness. It should be tight and free from excessive water, and compacted to the correct density. When an inspection shows that proper conditions exist, placement may begin but must be limited only to those areas ready for gravel. Soft areas may occur from time to time after the aggregates are laid and exposed to the wheel loads of hauling units or other traffic. The action of vehicle travel has a tendency to tighten the surface of the aggregate as well as revealing potential trouble spots, so traffic should be encouraged to travel over the newly placed aggregate wherever it is practical to do so. Then soft spots can be corrected as they occur before additional material is placed over them.

In some instances, the supporting ability of the sub-grade and aggregate courses is adequate only when the total structural depth (including plant mix or concrete surface) is completed. Under these circumstances trouble will be encountered trying to support the vehicles hauling aggregate. In these cases, travel over the placed surface is to be kept at a minimum. The least amount of hauling over the completed course can be achieved by beginning at the furthest haul point and proceeding toward the loading point.

It may be necessary to keep loadsdown to legal limits. Uniform distribution of water will result in the best relative compaction with the least amount of effort. Proper application neither too wet nor too dry, will eliminate the chance of repairing base failures just ahead of the paving operation. The Standard Specifications provide that aggregate bases are to be watered as directed by the engineer because the State wants to retain control over the quantity of water used and the time the watering is done.

The aggregate must be properly spread after hauling to insure that the correct tonnage per station has actually been applied, and the correct surfacing thickness will result. When the surfacing aggregates are measured and paid for by the ton the inspector must measure the distance each truck load is to be spread to assure that the correct tonnage will be applied and provide the correct depth. A spread sheet containing a tabulation of the distance each ton will spread for the thickness of lift to be used, should be made up in advance for each type of aggregate surfacing. Then as placing operations progress, the tonnage actually placed should be compared with the distance travelled down the roadway. The quantities actually placed should be in reasonable agreement with the planned quantities. However, adjustments may become necessary when the unit weight of the material being placed does not agree with the unit weight estimated on the plans. The two most important factors in aggregate placement are:

1. Each lift of surfacing aggregate must be properly compacted.

2. The correct depth must be achieved.

When these factors are overlooked, soft spots, lack of durability and improper supporting power will result.

The aggregate surfacing inspectors duties are many but consist primarily of:

1. Assuring that the correct quantity of material is on the roadway by measuring spreads and comparing with planned quantities.

2. Observing the watering and compaction operation to assure that a uniformly dense mat will occur.

3. Checking that the surface depth and smoothness of the finished surface are correct.

4. Recording his comments and such information that pertains to the quantity of material hauled, placed or spread in any particular day or shift and accounting for errors or irregularities such as voided tickets, correction of soft areas and rejecting obviously poor material.

In times past, spreading of aggregate surfacing material was universally done with a motor patrol which, when operated by a skilled workman, could provide a surface with the proper smoothness, correct section and very little segregation. However, with the advent of wider roadways, material processed by a motor patrol is worked through too great a distance which promotes segregation and is time consuming. Aggregate spreading equipment, some self-propelled and other equipment that is pushed or towed has been developed to solve these problems, and operate generally on the principle that the less maneuvering of the aggregate material is better. The intended cross section and smoothness should be obtained with a minimum amount of manipulation of the aggregate, because manipulation will lead to segregation and in the case of soft aggregates lead to possible degradation. Any spreading equipment that is used or intended to be used, is not supposed to cause segregation, but if segregation does occur the equipment should be removed or corrected before any further work is done.

Frequent checks should be made during the course of the work to determine the thickness of the loose versus compacted aggregates so that a definite correlation can be made early in the job. This correlation is necessary so that the depth of the loose material that is required to produce the specified compacted thickness is known. Material compacted at different densities will naturally vary in thickness, therefore, the inspectors should be on guard for any variations in uniformity of compaction or of material being placed. The thickness of the aggregate base can be checked by placing a piece of paper or pouring a thin layer of cement on top of the sub-base or sub-grade. Then after the lift is completed, dig to the cement or paper and measure the thickness of the overlying material.

The contractor has his choice of what equipment to use in hauling, placing, spreading and compacting aggregate surfacing material. He may desire to use equipment that is not listed in the Standard Specifications but will give satisfactory results; this should not be discouraged. An inspection of the equipment intended to be used or being used, along with various material tests can easily be made to determine if that equipment will produce results conforming to the specifications. Faulty equipment or equipment with border-line result capabilities are not to be used.

45.06 Automatic Grade Control

Grading control has in the past, been almost **exclusively** performed with bluetops as guides. This is an expensive and time consuming method and a new system has been developed that reduces both the time and material cost. The system of using anywhere from 3 to more than a dozen bluetops every 25' or 50' may be replaced by an electronic grade control attachment mounted on a motor grader, 2 shoulder bluetops per section, and a grading surface guide parallel to grade.

Motor graders equipped with Automatic Blade Control (ABC) operate using a preset surface, wire, or nylon string as a guide or datum line for the sensing device. A sensing device with a follower wheel or arm is attached to the grader blade. As the follower rides along the guide, roadway dips and bumps cause the follower to move up and down. The follower's vertical movement signals the sensing device to send electrical current to activate a servo valve. The servo valve in turn causes a blade lift cylinder to extend or retract, thereby restoring the blade to guide relationship. The ABC may be set for any right or left slope between 0% and 20% and the machine will cut this slope on a grade parallel to the grade guide.

If the contractor wants to use ABC equipment, State personnel will set bluetops to grade on one shoulder of each set of lanes and contractor personnel will set the guide to meet their own requirements. As the nylon string is the least expensive and most commonly used guide, the remainder of this discussion will be based on this type of guide.

The cutting edge of the blade is set on top of a bluetop and the string line set so the follower arm contacts the string. The distance between string line and bluetop is measured and this distance is used to set the string line above the remaining bluetops. This establishes the blade-to-string line relationship. A counterweight on the follower arm allows the arm to operate above or below the string. Under-the-string operation is preferred. The follower arm must stay in contact with the guide string.

The crown and super also have to be considered, and this is achieved by the correct percent of slope on the slope control dial which automatically adjusts the blade to the set slope. The blade will maintain this percent slope from the grade line until a new setting is made. As the grader proceeds across the road on consecutive passes the operator overlaps the blade approximately one-half of its length on the surface of the previous pass in order to continue carrying crown slope to center line of lane. This slope is carried a few feet past center line in order to have a true grade at centerline to work from. Guide stakes are placed by the contractor on centerline of lane every 200 feet. Using this line as a guide for line and grade the grader is able to start from the surface grade at centerline and continue the crown slope on to the shoulder. In other words, the grader is capable of constructing surface guide from shoulder to shoulder using one line of bluetops whether on a tangent or curve section. A steel wheel roller should be operated directly behind the grader so a smooth compacted surface is left for the grader to use for grade line on the next pass.

On curve run-off sections the percent of super is posted on a lath every 50' where it is readable by the operator. When the grader passes the posted percent of super the operator sets the slope control dial at the percent shown. This procedure is continued until the full super is reached.

The use of ABC equipment is extremely limited at the present time. This section is included only as an introduction to this kind of equipment so that State personnel will be aware of its use and possible advantages.

45.07 Maintenance of Completed Base Surfaces

The contractor is required to maintain the surface of completed aggregate courses in preparation for traffic and for protection from adverse weather. A little maintenance done frequently is much better than waiting until considerable rutting, pot holing and segregation occur which will then require heavy processing, blading or other repair work, and which will incur adverse public comment because of rough roads, flat tires, etc.

45.08 Records

Proper records can be made after testing, observation, and inspection functions have been performed to determine acceptance of the various materials, equipment and methods employed by the contractor. A list of some of the more important inspection activities is shown below, for the inspector's guidance. The inspector or tester may add to this list those activities which he thinks are important, remembering that absolute compliance with such lists as given in manuals including this one, is not a mandatory requirement but meant to be a guide for doing the work properly and keeping the product within the specification requirements.

1. Check all special provisions and plans for any unusual requirements pertaining to the pit. (Area to be excavated, side slopes when finished, stripping of over-burden, depth of excavation, land-owner agreements, etc.)

2. Know where different materials (layers of sand, boulders, silt, clay, etc.) are located in the pit then watch for radical changes in material going into the crusher and coming out of it.

3. Take enough samples for sieve analysis, fracture, moisture tests, etc., so that the minimum sampling frequency is met. The inspector who keeps busy, is happier and provides a much better control of production than one who only does the minimum.

4. Look for segregation of material going into stockpiles or when loading trucks or unloading trucks, then require the contractor to correct any segregation that does occur.

5. Keep a complete record of all field tests and inspections and be sure the contractor is informed of test results. This is especially important when production is borderline.

6. Make occasional checks of the accuracy of weighing equipment using the 50 lb. weights. Both the platform scales for weighing trucks and the smaller scales used in testing are to be checked. The Lab personnel should be asked to do the checking or set up a procedure for checking that can be followed easily by project personnel.

7. When stockpiling aggregate make sure that the stockpile area is correctly prepared, material is correctly placed, segregation or degradation is kept at a minimum, piles of different materials are separated and all stockpiles are neatly finished.

8. Each truck load placed by the ton must have the length of spread taped. Do this accurately and the quantities spread will be equivalent to quantities planned, providing of course, the unit weight and compaction are as planned.

9. Make sure that the roadbed surface is ready for the aggregate surfacing course, then see that each succeeding course of aggregate is well compacted and its surface correctly finished before the next course of aggregate is placed.

10. Avoid over-watering and be sure that water is uniformily distributed. Over-watering can easily cause soft spots in the sub-grade or underlying aggregate surface courses previously placed.

11. Make sure that each surface course is completed and compacted to the true profile and correct cross section.

12. Aggregate surfacing can be placed and trimmed to the exact elevation at each bluetop and yet be irregular between the bluetops. Make sure that no humps, bumps, sags or depressions occur in the profile along the shoulder line, quarter line or center line, and curve transitions or other critical points along the roadway are true.

13. Be sure that the surfacing is being properly maintained.

14. Keep daily records of the material produced, tests taken, discussion with the contractor or other personnel and the general activities surrounding the surfacing operation.

A sample set of notes has been prepared in Figure 45-1 to show the general method of maintaining aggregate surfacing records. The example shown in this figure is to be used as a guide by each Project Manager when he sets up his note-keeping system.

Since each project may have details that differ from other projects, the note-keeping records from one project may not agree identically with those from another project, but each record keeping system employed should have its basis in the sample shown, recognizing, of course, that other records are needed to supplement the daily record of where aggregate was placed. These other records would include Form 123 for aggregate testing, aggregate surfacing diary, unit weight computations of the aggregate, computation for spread lengths, scale sheet, scale testing information or weigh tickets and weigh cards and records of quantities obtained from each pit.

The various records and notes made of the quantities and qualities of the materials, water supply, discussion pertaining to contracts with owners of borrow sites, types of equipment used and discussion with the contractor pertinent to the work should be as complete and accurate as possible. The inspector collecting all the weigh tickets or punch cards whichever is used, should make frequent checks of the planned versus the actual quantities of material placed during working hours. If spare moments to do this will develop. Quantities taken from the weigh tickets or punch cards should be posted on a daily basis or soon after receipt in the field office as is reasonably possible. Tickets received on the last shift of one day should be posted in the aggregate surfacing notebook no later than the end of the last shift on the next day of work.

Payment for aggregate measured by the ton, will be based on the scale weight of the material, which weight will include the actual quantity of natural moisture, up to and including a five (5) percent moisture content. Water above the natural moisture content, added by the contractor at the direction of the engineer, will be deducted from the weight of the aggregate and paid for as a separate item.

The quantity of water introduced into the materials by the contractor must be determined and a proper reduction made to arrive at the correct percentage of moisture to be paid for as a separate contract item (water surface courses). The following formula can be used to determine the quantity of aggregate to be paid for. The scale weight times the ratio of 1+ the natural moisture content all divided by 1+ the total moisute content equals the weight of aggregate to be paid for and can be expressed as follows:

$$Sw\ \frac{(1 + Mn)}{(1 + Mt)} = Pw$$

Sw = Scale weight including all moisture.
Mn = Natural moisture content.
Mt = Total moisture content.
Pw = Pay weight of material weighed.

This formula is used in the sample notes in Figure 45-1. In this figure all weights on the "Total to Day or Shift" line are scale weights (SW). The "Moisture Correction $\frac{1.05}{1.06}$ " is the numerical expression of $\frac{(1+Mn)}{(1+Mt)}$ and the weights on this line are Pay Weights (Pw) that result from multiplying the Scale Weights times $\frac{1.05}{1.06}$ or $Sw\ \frac{(1+Mn)}{(1+Mt)}$.

In all cases material containing more than five (5) percent natural moisture shall have the excess above (5) percent deducted from the scale weight. Adjustments should be made in spreading each load by the roadman and a moisture correction made at the end of each shift on the total number of tons hauled. This can be done using the formula above with Mn=0.05. In this way payment to the contractor will be correct and the state will have received and spread the correct tonnage.

When the "Control Strip Method" (ref., MT-219 and Std. Spec. 20.05 (d) is used, measurement and payment for all work involved in the construction, watering, compaction and maintenance of each control strip and each test section shall be absorbed in the unit price bid for the respective surfacing aggregate.

DATE	STATION		LIFT	TONNAGE		PLACED		ACCUM.	PLAN		
	FROM	TO	NO.	ROADWAY	APPR.	REINF	WIDEN'NG	TOTAL	TOTAL		
	Total	brought	fwd.	5,000	420	210	35	5,665	5,668		
6-30-67 Shift 1 of 2	31+78.5	36+22.3	1 of 2	396					392		
	36+22.3	51+12	1 of 2	1,332					1,321		
	Approaches										
	Lt sta. 62+00				41.0				*40		
	Lt sta. 69+00				39.0				*40		
	Rt sta. 50+00				42.0				*40		
	Reinf										
	Backfill Soft area										
	sta. 61+50 to 62+00					100.0			98	*Pro-Rated	
	TOTALS	TO DAY	or SHIFT	1,728	122.0	100.0	~	1,950	1,931		
	MOISTURE CORRECTION $\frac{1.05}{1.06}\times$			1,711.8	120.8	99.0	~	1,931.6	~		
	ADJUSTED	TOTAL TO	DATE	6,711.8	540.8	309.0	35	7,596.6	7,599		

REMARKS

Weather - 90°+ Hot & Clear
Shift - #1 worked 4:00 A.M. to 12:30 P.M.
Personnel - Tester P. Lyle
Scale A. Wells
Road P. Palmquist

Material being obtained from J. Jones (owner of pit lab.# 330862-72) 1½" base material within "specs." through out shift & uniform 15 tests. Placing in typical section #4 with Jersey spreader. Avg H_2O=6%

Ticket # stop	258846
Ticket # start	258582
# tickets	264
# loads	265

Ticket # 258601 void - Truck broke down & contractor wasted load.

Recorded by: Paul Palmquist 6-30-67
Computed by: Dick Oldenmyer 7-5
Checked by: Dick Bly 7-7-67

FIGURE 45-1

Figure 45-1 shows a sample form of aggregate notes that had been prepared from a Primary project with numerous typical section breaks, the usual curve widening, approaches and reinforcing and other items that are necessary to be recorded that are typical for most projects, whether Secondary, Primary or Interstate, such as two or more shifts, correcting the scale weight for excess moisture in the aggregate, keeping track of the lab pit number from which material is being obtained, placing the material into two or more lifts, etc. Although Figure 45-1 is intended as a guide, it does include most of the problem areas that torment the project personnel. Any of the problems of note-keeping can be controlled by using plenty of paper, not wastefully but efficiently. For instance, if there are project splits in the contract one set of notes should be maintained for the "F" portion and another complete set of notes for the "FG" portion, of the "I" and the "IG", or whatever designation the project splits would take. Then notes for each project split should be placed in a separate notebook folder and labeled so there is no mixup as to what quantities were placed where. For instance, if the contract contained an "F" and "FG" portion, the two separate aggregate notebooks could be labeled as follows:

F-99 (21) Sta. 10+00 to Sta. 89+10

Then the other notebook for the other portion of the work can be labeled as follows:

FG-99 (21) Sta. 89+10 to Sta. 318+18.6

Similarly, if one contract contained more than one project, separate notebooks must be maintained for each project in the contract.

It is recommended that one page be used for each shift or each day's work, rather than placing more than one day or more than one shift on a single sheet. In this way, there is usually sufficient room left for proper remarks about happenings on that shift, and an adequate number of columns can be maintained for easy recording of approaches, reinforcing, widening, connections, frontage roads or other similar details. One thought that will guide an inspector or recorder in making the proper entries is a review of the summary sheets in the plans showing that the project notes must provide this same form of information both for the final quantities and for progress estimates, it can be easily seen that a proper daily recording, summarizing or sub-totaling of tonnage placed at the different points throughout the project can greatly aid speedy and accurate preparation of estimates and finals quantities.

Some of the information that is vital to accurate record keeping is knowing the tonnage placed on the mainline from station to station, location and summary of all additional surfacing placed, weather information, what shift is being worked, the personnel, where material is being obtained, the lab pit number, is the material within the specification limits and, if not, what corrective measures are being taken to overcome the problems, if moisture is being deducted, the computations and moisture adjustment must be shown in the notes on a daily basis. Comparison must be made between the number of loads weighed and the number of tickets accepted. The names of personnel who recorded, computed, or checked each sheet are to be placed in a convenient place on each page along with the date.

Many of the aggregate sources encountered are extremely wet and as mentioned previously, require a moisture deduction from the weight of the aggregate prior to payment. The method of deducting moisture must be agreed on, before hand, through discussion with the contractor. It may be easier to make adjustments for moisture content on a load by load basis to correct the spread. The correction and quantity adjustment is to be based on moisture samples taken for the purpose, providing, of course, the contractor is agreeable to such procedure and that correct depth of aggregate will be placed. The Project Manager and inspectors are again reminded that it is much more important to place aggregate surfacing to the proper depth than it is to place the planned tonnage. This is because the design is based on the depth required to support the loads and then this depth is used to compute the planned tonnage. The planned tonnage is used in the field only as a help in placing the correct depth but can become misleading when significant changes in volume occur. For instance, if the unit weight of the aggregate is not the same as the planned weight a different volume will occur and similarly if a certain percentage of the volume is composed of water, a reduction in the planned surfacing depth may occur.

45.09 Scaleman's Duties

All aggregates are weighed at some time or another before being placed on the project site. Therefore, in order to allow the contractor proper payment a scaleman must approach his duties with utmost regard.

If possible the scaleman should be allowed to observe the scale assembly operation so as to become acquainted with the function of the apparatus. After the scales are properly installed they will be checked by a representative of the Division Materials Lab to insure accuracy and from then on the responsibilities lie with the scaleman. The following items are points which should be under careful surveillance:

1. Working parts and scale platform shall be kept clean at all times.

2. A continuous examination of the scale platform to be certain there is clearance between the platform and foundation.

3. The zero balance shall be tested, and adjusted if necessary, several times daily.

4. The operator's weight should be included in the weights taken.

5. Be sure that all of the vehicle being weighed is on the scale platform.

6. All vehicles shall be tared twice each shift.

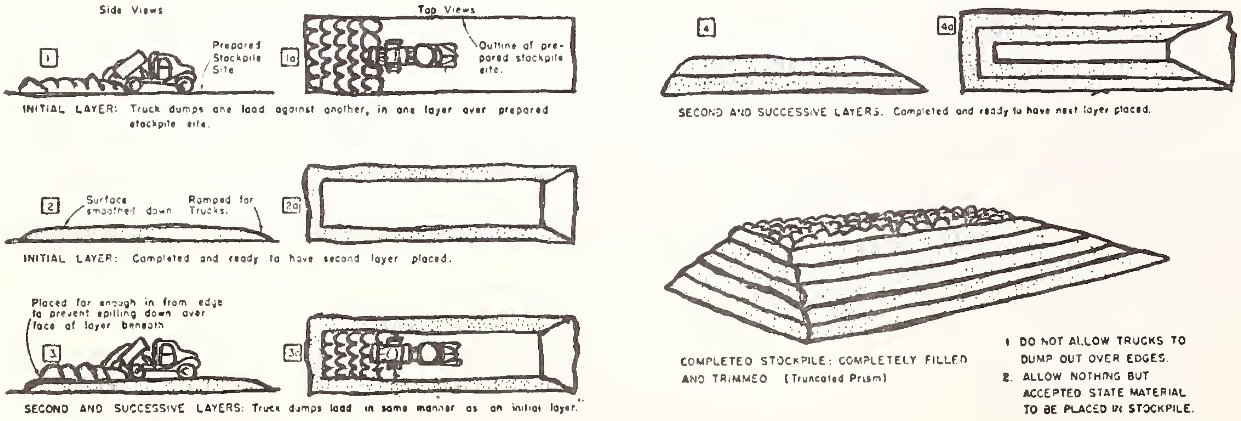
7. Do not allow total loads to exceed the capacity of the scales.

8. Use the triplicate ticket form to record the Project Number, date, etc., and weight of material hauled by each truck, each trip. Write your initials on the ticket (DO NOT PRINT) and send the white and yellow copy with the truck driver and keep the pink one for the scalemans records. Do not initial tickets except at time of actual weighing.

9. Then at the end of each shift totals for that shift can be compiled to determine how many tons were hauled per truck; tons per shift; and where this tonnage was placed. The one set of tickets sent with the truck driver will be delivered to the roadman so a cross check can be made of figures for the shift.

The Project Manager shall inspect the weighing procedure often enough to insure himself that it is being conducted properly.

PROCEDURE FOR STOCKPILING AGGREGATES


Side Views
Top Views
1
Prepared Stockpile Site
1a
Outline of prepared stockpile site.
2
Surface smoothed down
Ramped for Trucks.
2a
Placed far enough in from edge to prevent spilling down over face of layer beneath
3
3a
4
4a

INITIAL LAYER: Truck dumps one load against another, in one layer over prepared stockpile site.

INITIAL LAYER: Completed and ready to have second layer placed.

SECOND AND SUCCESSIVE LAYERS: Truck dumps load in same manner as on initial layer.

SECOND AND SUCCESSIVE LAYERS. Completed and ready to have next layer placed.

COMPLETED STOCKPILE: COMPLETELY FILLED AND TRIMMED (Truncated Prism)

1. DO NOT ALLOW TRUCKS TO DUMP OUT OVER EDGES.
2. ALLOW NOTHING BUT ACCEPTED STATE MATERIAL TO BE PLACED IN STOCKPILE.

FIGURE 45-2

Rev. 5-1-73

IV-46 Cement Treated Base

46.00 References

Standard Specifications, Section 22

46.01 General

Cement treated bases are composed of a mixture of Portland Cement, graded aggregates and water. The ingredients are tested for quality and are uniformly combined in the correct quantities to form a more sturdy surface underlayer than the untreated aggregate. Portland Cement furnishes a limited amount of slab strength to the base but also improves the quality and stability of the base. The principal advantages of C.T.B. are; improvement of the structural section, increase in erosion resistance and minimizing pumping action by the concrete slab.

Uniformity is a key word in cement treated base construction. Lack of uniformity will result in substandard material immediately under the pavement which can deteriorate and eventually fail under traffic loads. The aggregate grading must fall within specification limits and ideally it should be uniform within those limits. Daily fluctuations in grading are to be avoided. A changing cement content is inadvisable because a non-uniform strength will result. The water-cement ratio, once established, is to be kept uniform. Similarly, compaction must be adequate and it must be performed uniformly throughout the full width and length of the cement treated base.

Design strength requirements have not been listed in the specifications but do become a part of the desirable testing requirements and are under the control of the Division Materials Section. A variable water-cement ratio and capacity to achieve high strength will exist in different areas because of the wide range of aggregate quality available within the State. The ratio used in one area may not be desirable in another. The Materials Section is concerned more with durability and uniformity of compressive strength than with the actual strength value providing, that test results are sufficiently high to achieve the needed strength and durability (usually in the vicinity of 400 to 1000 psi. 28 day tests).

Preliminary estimates establish the percentage of ingredients to use but construction testing establish the percentage of ingredients to use but construction testing must be performed to confirm the preliminary test data. It is the Resident Engineer's responsibility to see that quantities and percentages are correct during construction and should not take the preliminary estimates too literally. If preliminary information is confirmed original plans can be followed, but if disagreement exists, the matter is to be referred to his supervisors so corrective measures can be taken and adjustments made where necessary.

46.02 Roadbed Preparation

The roadbed upon which the cement treated base is to be placed must first be shaped to the proper cross-section, contain the correct density and exhibit the surface smoothness as specified. The roadbed cross section can be easily checked for trueness to crown or super elevation at the blue tops but this area is only one place to check. Intermediate areas are also to be checked for trueness in both the transverse and longitudinal directions and any additional shaping done as needed before C.T.B. placement can begin.

All soft spots must be dug out or otherwise corrected and the subgrade made structurally sound because the cured cement treated base does not develop enough slab strength to bridge soft areas. Uniformity in the subgrade is necessary to promote durability and supporting power for the overlying surface courses.

Accurate shaping is necessary to provide control for thickness and surface shape of the C.T.B. since the full depth is placed in one continuous operation and is not subject to further manipulation or adjustment after it is originally placed. A trimming operation is used but any corrective measures are limited because this procedure is used for only minor adjustments of the surface.

46.03 Mixing

Cement aggregate and water may be mixed in place on the roadbed or mixed in a central plant and hauled to the roadbed. The primary consideration in mixing, regardless of method used, is uniform introduction and mixing of the ingredients. The equipment intended for use shall have undergone a thorough inspection to determine its suitability for the work and to assure that its capacity is adequate.

Different methods have been successfully used in the past to provide a satisfactory cement treated base.

1. Mixed in place: The in-place roadbed material can be scarified and pulverized, mixed with cement and water then relaid.

2. Road Mixed: The aggregate can be graded, hauled to the roadbed, windrowed, then mixed with cement and water and laid.

3. Plant Mixed Aggregate: Cement and water can be mixed in a central plant, loaded, then hauled to the roadway for laying.

The Standard Specifications permit roadmixing and central plant mixing whereas a mixed-in-place cement treated base, if used, would be set up as a special provision on a job-by-job basis. Mixing will be generally limited to central plant mixing where control of the ingredients are more easily made.

Roadmixing necessitates the use of a machine that will pick up or thoroughly mix all of the windrowed material on the roadway. Untreated material left on the grade will result in a section of low durability and one deficient to design standards. Excessively large windrows result in inadequate mixing because of overcrowding in the mixing chamber. Machine capabilities must be matched with windrow size, the steepness of uphill grades and other factors, if mixing is to be complete.

Uniform distribution of cement is very important if curing, skrinkage, strength and durability are to be uniform. The quantity of cement spread may be checked by placing a piece of paper on the untreated windrow then weighing the quantity of cement collected after distribution.

The specifications permit mixing at a central plant by use of a pugmill. Pugmills, either the batch type or a continuous flow, are to be equipped with feeding and metering devices that will add the correct quantities of ingredients uniformly. Cement and aggregate are to be dry mixed a few seconds before the addition of water. Water should be added by sprays to promote more uniformity in mixing, thus aiding spreading and compacting. Cement is probably more difficult to add than the water and aggregate because of its tendency to occupy different volumes under different conditions. Cement that is fed from a constant head (cement agitated by air or other means to keep it in a uniform condition) will flow more uniformly into the pugmill. The contractor is responsible to control all ingredients within the tolerances assuring that a specification product is delivered. The engineer can assist in the plant calibration and is obligated to make the necessary checks to assure uniform production but is not required to accept responsibility for the quality of the product. He should conduct himself so that he will not become responsible for a faulty product by refraining from making adjustments on equipment or giving directions on equipment usage. However, suggestions are almost always welcome.

46.04 Placing & Finishing

Cement begins its hydration process as soon as water is added to it, therefore, time becomes increasingly critical after water has been introduced into the mixture. Time delays are to be avoided as should long hauls. The length of each section being spread should be limited to a distance which can be compacted and shaped within 2 hours after mixing and finished within 2 hours after compaction. The quantity of moisture present, in the mixture, should be observed closely during compaction by the road inspector who should advise the plant inspector when undesirable changes in moisture content occur. Dry mixes are difficult to work and result in minimal densities compressive strengths and durability. Whereas excessively wet mixes result in segregation,loss of strength and lack durability.

Cutting and trimming is done during placing and compaction but may become necessary after compaction is completed. When this additional trimming is necessary the trimmings are to be removed from the surface and wasted. Cuttings placed in depressions at this stage of curing will not bond properly with the surface and become loose when subjected to traffic.

The surface of the C.T.B. must be sealed to prevent moisture loss, after shaping and compacting, so that curing can proceed correctly. Asphalt material is used for this purpose, and care shall be taken to achieve full coverage with a continuous thin film. Excessive amounts should be avoided.

The seal must be maintained and no traffic should be allowed on the base throughout the specified curing period. When light traffic must be allowed to cross newly placed C.T.B., such as at a local road intersection, a few inches of aggregate covering material should be placed over the C.T.B.

46.05 Inspection and Records

The C.T.B. inspectors' duties may vary somewhat from job to job because of circumstances peculiar to one project which require changes in inspection manpower, a different approach to inspecting at the plant and roadway or other changes in procedure. Therefore, the following list is offered as a guide for inspecting the usual project but may be modified by field personnel as necessary to fit different job conditions:

1. The plant inspector is responsible for proportioning the mix. Making checks of the cement content frequently during the days run and after each new load of cement is added to the silo; frequently checking the aggregate gradation and moisture content.

2. The inspector on the road is responsible for placing, compacting, shaping and sealing in addition to performing compaction tests; making smoothness and thickness checks and making C.T.B. test cylinders.

3. Personnel will be assigned as necessary to carry out such duties as weighing the aggregates, observing the subgrade preparation and helping perform the needed testing and inspection duties.

4. Inspection is to be made of the contractor's equipment for its capability. Rated capacity or production rates must be equal to the job. Hauling vehicles are to be in reasonably good condition and of sufficient number to support continuous production. Spreading and compacting equipment must be capable of "staying up with" the production and hauling equipment.

5. Testers and inspectors must be properly equipped (10' straight edge-compaction testing equipment, sieves-balances-test report form-fuel and electrical supply-cylinder kit, etc.), and have been provided the background information to control the work i.e. mix designs and maximum density curves from the laboratory.

6. Records are to be kept on a daily basis in the project diary and in other diaries kept as deemed necessary by the Resident Engineer. Records would include information about what equipment and materials were used, delays and their cause, breakdowns and their effect on other phases of the work, tests taken that failed and corrective action taken to remedy the situation, etc. Reports on compacted density and optimum moisture along with test cylinder data are to be properly recorded. The yield and area placed should agree. Records are also to be made of any changes or variations made in construction methods and the results of these changes on the roadway section affected.

IV-47 Asphalt Concrete Pavement

47.00 References

Standard Specifications, Section 30 and M-120

47.01 General

Ashphalt materials find a wide usage in the construction industry. The asphalt consumed for highways, airports and other paving is approximately 70%, roofing material about 20% and other miscellaneous usage 10%. Pavements constructed with asphalt products are called flexible pavements as distinguished from those pavements made of Portland cement which are classified as rigid pavements. Flexible pavements can be a low type pavement or a high type pavement. The low type asphalt pavements are generally constructed with cutback or emulsified asphalts of RC, MC, SC or SS, etc., whereas high type asphalt pavements are constructed with an asphalt cement. Generally, the low type asphalt pavement is used to support light wheel loads and light traffic volumes and the high type asphalt pavements, called asphalt concrete, are used to support heavy wheel loads and high volumes of traffic.

To be successful a flexible pavement must have several properties. It must be stable and dense, yet have a surface texture that promotes skid resistance. It should be durable, economical and, of course, flexible. A flexible pavement will deform slightly under wheel loads and the deformation may be either plastic or elastic. Plastic deformation may result in permanent ruts and ridges, whereas elastic deformation occurs when the deformed area returns to it approximate original position without incurring a permanent set. Elastic deformation actually benefits a pavement and results in its longer life by keeping the asphalt "alive" through the light flexing of repeated rubber tired action.

Asphalt concrete is composed of a combination of aggregates and asphalt. The aggregates are theoretically graded to progressively fill the voids in the next larger fraction and the asphalt material is used to bind or cement the total mix together. Central plant mixed asphalt concrete has important advantages over road mix placed asphalt surfacing because closer controls can be imposed on moisture, temperature and asphalt content thus resulting in closer approximation of the ideal mix.

Other advantages which result in greater uniformity are:

The asphalt and aggregate materials are heated before being mixed. This allows use of heavier grades of asphalt. The working season can be extended because the preheated mixture is heated and can be more easily handled in cool weather. The plant can be shut down during adverse weather thus avoiding the time loss that a similar road mix operation would experience when drying material which had previously been placed on the road. Greater densities and smoother lay down can also be obtained.

Plant mix pavements are constructed according to the designation of Type I (no-bin separations), Type II (two bin separation), or Type III (three or more bin separation). Type I and II have less rigid aggregate blending requirements and are somewhat less strict in the grading requirements than are the Type III plant mix pavements. The choice of pavement, whether Type I, II or III, is based on the traffic volumes, subgrade support, type of aggregates available and the roadway design (Interstate, Primary or Secondary).

47.02 Roadbed Preparation

Roadbed preparation for asphalt concrete pavement is similar to preparing the road bed for any type of surfacing. Soft areas must be cured, surface smoothness should be within the specification tolerance (on the normal roadway section) and the super elevated sections must be true to the design intended. Necessary adjustments are to be made in the surface or base section before plant mix operations can begin. The cross section and profile can be easily checked by using levels, a string line, or a wire stretched between bluetops. A night inspection under headlights may reveal many irregularities in the aggregate surface which are unseen by daylight. All serious irregularities must be corrected before priming or plant mix operations can begin. Each successive operation from preparing the sub-grade to placing, compacting and trimming the gravel surface courses must be closely controlled to prevent over-watering, segregation of the material and inclusion of defective material. Each of these deficiencies, when they occur in one layer, can quite often be transmitted to the layer above or below. For instance water used to control dust or aid in obtaining optimum moisture in the surface aggregates may trickle through these aggregates, saturate the subgrade and result in a soft area which then must be scarified and aerated or otherwise corrected.

Reshaping of the aggregate surface may be necessary prior to priming because of imperfections caused by traffic or resulting from the contractors operation.

A prime coat is placed on the upper surface of the aggregate to protect the base from destructive action of traffic, minimize moisture penetration into the base material and to provide a firm surface upon which to place the hot asphalt mix. The liquid asphalt used for prime coat must be applied in the correct quantities. Too heavy an application is not only wasteful, but may cause slippage, instability or bleeding in the finished pavement. Too thin an application may result in a surface requiring repair before paving.

In street sections, catch basins, manholes, or other similar facilities may need to be adjusted to the proper elevation. In some instances the adjacent pavement curb or curb and gutter may have to be adjusted. In other instances, the old surface material must be removed from street intersections and adjacent areas to provide the proper grade, crown and drainage for the finished pavement.

Existing joint fillers should be removed to an elevation of about 3/4" below the surface of the pavement when old concrete pavements are to be resurfaced. If this is not done, the joint filler may bleed into the asphalt mat after the hot material has been placed. This bleeding can cause the mat to shove when rolled which then may result in a bump. Holes and depressions in the foundation should be patched and brought to the required elevation and properly compacted before the hot asphalt plant mix is placed. Holes that are patched but not compacted will cause a depression in the finished pavement so it is necessary to compact all patches made.

The paving operation will proceed more uniformly when the surface upon which the plant mix is to be placed has been properly finished to the correct elevation. Tack coats are required between each lift of plant mix surfacing. Although other asphalts can be used, SS-1 is preferred. Application should be from 0.02 - 0.05 gal/yd^2 and very rarely above .05 gal/yd^2.

47.03 Mix Design

Samples of the various aggregate sizes, including blending sand if required, are to be submitted to the Materials Laboratory for testing and design of the asphalt concrete mixture. The mix design is made for the purpose of establishing the correct gradation, asphalt content, stability, voids percentage and flow value. Mix designs help achieve a long service life by correctly proportioning and controlling the mix constituents. Occasional field adjustments may be necessary in the mix design (job mix formula) to better utilize available aggregates within their gradation limits and still abide by the specifications. Adjustments made in the mix design must fit the allowable tolerances, and the specifications established for the job, and should be communicated to the Materials Division by proper notations made on the daily plant mix form.

Previous aggregate sources may be used for future work and even though such sources have been tested and investigated it is important to have re-checks made to assure that quality and quantity are acceptable.

Mix design methods in Montana utilize the Marshall Method for determining the range in which stability, flow, and voids should fall. Stability values may range from near a thousand, with rounded aggregates found in the eastern part of Montana, to over 3000 when using the heavily fractured aggregates in western Montana. Values of flow range from a low of near 8 to a high of around 16 with values near 12 desirable. The percentage of voids will generally range from about 3 to approximately 7 with values near 4 desirable. Mineral filler may be added to the mix. Its need is determined by laboratory methods, using Marshall and Immersion compression tests which are used to promote durability and improve asphalt film thickness. The design needs of flow, percent voids, stability and asphalt content must be in proper relation, for best use of the particular aggregate. For instance, high stability values may be obtained by reducing the flow value, but pavements made of such mixtures tend to be more rigid or brittle and may crack under heavy volumes of traffic. Therefore, high stability may not be a desirable factor when it is achieved at the expense of flow or voids. A reasonable stability value, consistent with the aggregates produced, (rounded aggregate need more care than fractured aggregates) should be strived for and shifted when necessary.

47.04 Plant and Inspection

A. General

Two types of plant operation exist. One is the permanent commercial plant, with multiple production operations centrally located, from which mix is transported to a job. The other is a portable plant that is erected on or near the project to produce the mixture for that project. These portable plants are much more common and may be either continuous flow or batch plants.

The Engineer must thoroughly examine plant equipment and become familiar with different plant features. The mechanical condition of each component is to be inspected for safety and proper function. Mixing and production operations should not be started until all mechanical deficiencies and unsafe conditions have been corrected. For instance, if the sampling devices are so located that the inspector must balance on his toes, or climb on the super structure of the plant in order to obtain his sample, it is unsafe. Make it safe! The State does not expect you to risk your life or limb for an aggregate sample! However, we must have a sample so do require safeguards. Similarly, if the device used for putting mineral filler into the mixture produces a range of heavy and light quantities of mineral filler, it should be adjusted to be more uniform.

The testing trailer, or field laboratory should be so located that all of the plant operations are in full view. Park the trailer or lab out of line of the prevailing winds. The Resident Engineer should be sure that all laboratory personnel have copies of the job mix formula, standard specifications, special provisions and a sufficient supply of the various forms to record all test results, materials received and mixtures produced. A laboratory should be equipped with the proper testing equipment, power supply, water and fuel for the stoves and ovens. Such other niceties as nude photos and the like are not really essential for proper field laboratory operation.

A job mix formula can, and should be changed to take advantage of or correct for changing stockpile gradation when the gradation is outside the job mix tolerance. Job mix formula limits should be set within the band of gradation limits and should be set to take advantage of the range of gradations expected. If it becomes necessary to change the job mix formula, the Marshall Tester should be requested to perform design checks on the produced mix, to assure the changes have been satisfactory.

A change in the source of supply of the asphalt should not be permitted unless serious difficulties are encountered. Then a change will only be permitted when requested and approved in writing. Similarly, if a change in the grade of asphalt appears desirable, all of the circumstances and details leading to the change should be placed in writing and approval gained before the asphalt grade will be changed. Changes made purely for the contractor's convenience are always discouraged. Consult the Construction Engineer in the event that the asphalt source or grade has been changed, because a re-design of the mix may be necessary before further production is approved.

B. Cold Feed

Mechanical feeders function from the stockpile or stockpiles or from bins holding the crushed aggregate and are set at a production rate that provides a uniform flow of cold aggregates into the dryer. Additional mechanical feeders may be necessary when blending sand or more than one stockpile is used. Each mechanical feeder must have feed adjustments that can be secured in any position.

The condition of material introduced into the storage bin and the feeder operation with its adjustments should be checked by the inspector frequently. The level of material in the hot bins may fluctuate widely because cold feed adjustments may have been improperly set or the gradation of the material entering the cold feed is improper. Excessive or numerous adjustments are not desirable and should be discouraged, since the change in the rate of feeding different aggregates will affect dryer operations, screening performance and uniformity of the mix.

C. Dryer

Cold aggregates taken from the stockpile move over conveyor belts into a dryer where the aggregates are heated to the required temperatures and excess moisture is removed. Dryers are composed of a revolving cylinder usually from 3' to 10' in diameter and from 20' to 40' long. A gas or oil fired burner and an exhaust system (to provide draft air from combustion in the cylinder). The exhaust system is powered by a fan, which is part of the dust collecting apparatus, but has its primary function in providing a draft for the dryer. Aggregates enter the dryer and are lifted by channels inside the dryer and then dropped through a veil of burner flame and hot gases. Drying time is controlled by the slope of the cylinder, its speed of rotation, length, diameter and the number of flights or channels.

The desired dryer temperature will vary from one job to the next job depending on many local factors. Generally the temperature that will afford the best spreading and compacting is a temperature that produces a mix within the temperature viscosity range. The specifications have established a temperature range for spreading. The minimum temperature is considered the lowest value for quality paving and the maximum temperature is specified to prevent overheating. Within this specified temperature range, lies an optimum mix temperature which may vary depending upon the source of the asphalt, the type of work being done, weather conditions, air and roadbed surface temperatures and other factors.

Several adjustments can be made in the dryer to obtain a more effective drying of the aggregates. Essentially the time element is the major factor in proper drying of the aggregate. Absorptive or excessively wet aggregates require a longer time than non-absorptive, or dry aggregates. If the aggregate is not being properly dried, time required for its passage through the drum may be insufficient and some adjustments should be made. Lowering the slope of the drum, reducing the speed of rotation, or some other way to slow the passage of aggregate through the dryer must be executed. Remember, the Engineer may make suggestions to the contractor for plant adjustment, but should not force these adjustments. Rather he should concentrate his efforts on the end result, either it is satisfactory and acceptable, or it is unacceptable and the contractor must make adjustments to improve the product.

Moisture content of the aggregate in the cold feed will tend to become high immediately after a rain, early in the morning and in the Spring or Fall when the weather is apt to be cool and damp. Take precautions to insure that the aggregates are being dried correctly. In most instances drying can be improved by decreasing plant production, however, this is not always the only correction necessary. The aggregates may also require aeration in the stockpile or screening unit or adjustment of the dryer exhausts fan efficiency or size. Adjustments other than those mentioned here may be necessary, and, of course, adjustments made on one plant, may not work on another plant, or even on the same plant under different conditions There-fore, no definite procedure can be set that will apply to all cases of drying or plant problems.

Some indications of improper drying or improper operation of the dryer can easily be noticed. For instance, an oil fired dryer may emit black smoke from the exhaust stack. This is an indication of incomplete combustion leaving free oil on the aggregate. An oily residue will make it difficult or impossible to obtain the correct asphalt film thickness. An insufficient draft through the dryer may result in frequent puffs of flame at the combustion end of the dryer or an intermitent rush and subsidence of flame through the dryer. A correctly set draft, balance with the right volume of fuel and air, will usually eliminate these problems.

A fairly uniform temperature range must be maintained and is essential for high quality work. A pyrometer (temperature measuring device) is used to indicate or record aggregate temperatures in the dryer. The business end of the pyrometer is a thermacouple which senses aggregate heat at the discharge end of the dryer and must be checked for accuracy, and sensitivity. Heavy armor placed around the thermacouple, inside of the dryer will retard the sensitivity and is usually an unnecessary protective device. The pryrometer can be checked by placing the thermacouple and a thermometer in a pail of hot sand or hot water and comparing the temperature readings. If the pyrometer fails to work or function properly, the contractor should be required to provide a substitute until the instrument is repaired. Inspectors and engineers should never attempt to repair or adjust pyrometers or other contractor's equipment.

D. Dust Collector

To prevent air pollution the Board of Health may require a wet scrubber. It is the contractor's responsibility to obtain needed permits, the Resident Engineer should be sure the permits have been obtained.

The exhaust fan in the dust collector system moves air through the dryer into the dust collector and out the exhaust stack. Heavy dust particles in the draft air fall into the dust collecting system as the lighter particles are driven out of the stack.

The dust collector then serves two purposes, one is to provide adequate draft through the dryer and the other to collect and remove dust. The dust collector must be capable of either returning the larger dust particle to the flow of aggregate uniformly or wasting them if necessary.

E. Screening Unit

As the heated aggregates leave the dryer they are transported by a bucket elevator into a screening unit where they are separated into the required size and deposited in separate hot bins. Oversize material falling into the screen deck is kept from entering the hot bins by a scalping screen. Holes in screens may let the wrong size or oversize rocks fall into fine aggregate bins. If oversize rocks appear in samples or in the mix, suspect holes or other troubles, and require repairs.

Even though the engineer may know exactly how to adjust the screens or correct the screening problems, he should not direct the contractor to make specific adjustments. Screening capacity or efficiency is affected by:

1. The shape, size of screen opening and the direction that slotted screens are placed.

2. Foreign matter in the aggregates.

3. The percentage of fractured aggregates and the shape of the aggregate particles.

4. The rotational speed, and vibration applied to the screens.

5. The condition of the screens regarding wear, holes, or plugging.

The screening unit should be cleaned frequently and a daily check made for loose, torn defective or otherwise impaired screens.

F. Hot Aggregate Bins and Gate

Each plant is to be equipped with bins designed to hold the hot aggregate which has been processed and screened into the various sizes required by specifications.

The partitions separating one bin from another are to be tight, free of holes and high enough to prevent aggregate from one bin flowing into an adjacent bin. The level of material in each bin is controlled by an overflow pipe that will discharge any excess aggregate from that bin.

Fine dust can build up in the corners of bins then discharge frequently in a quantity large enough to adversely affect the asphalt mixture. The buildup of fine dust in the corners of bins can be reduced by welding fillet plates in the corners.

The bottom of each bin is fitted with a discharge gate which may be operated manually or automatically. The gate closure should be positive to insure that no leakage of material into the waste box will occur. Aggregate samples are secured from gates or windows in the sides of the bins or by diverting the flow of the aggregates from the bins into the sample containers.

Before production begins, with continuous mix plants, a calibration of the aggregate flow from each feeder gate must be made. The rate that aggregates flow from each bin is determined by weighing the quantity discharge at various gate openings and then computing the quantity delivered per revolution of the feeder drive shaft. Each gate is then calibrated by plotting a curve which shows the pounds of aggregate per revolution versus the gate opening in inches. The operating speed of the feeder and the asphalt pump delivery rate for various sprocket sizes is shown in the manufacturers operating instructions, a copy of which should be furnished by the contractor. Various sprocket sizes for the pump must be checked by weighing a quantity of asphalt pumped into a container through a very carefully timed interval.

Temperature changes in the asphalt can change the percentage of asphalt put in the mixture. Temperature must be controlled within a very narrow range to control such fluctuations. A thermometer should be installed in the circulating line just ahead of the pump and the sprocket size for the asphalt pump checked for its delivery rate.

G. Scales (Batch Plant)

Aggregate from the batch plant hot bins fall directly from the bins into a weigh hopper in which batch weights are determined. A weighing mechanism suspends the weigh hopper and is equipped with a springless dial scale on which the weight of the aggregate from each bin can be marked. Markings should be accumulative and the last mark made to read the total quantity of aggregate in the batch. Once the sequence of weighing material from the bins has been set, it must be strictly observed for each successive batch in order that the accumulative mark on the dial scale will be correct for the material being weighed at that time.

When the plant is ready to operate, all of these scales should be cleaned and each part carefully checked to be sure that the scales are not binding but are freely supported. The contractor is required to furnish enough weights to check the accuracy of the scales. The scale check is to be performed by the Division Laboratory personnel (deputy scale inspectors) and then sealed. After the plant has been in operation for a short time, the scale should be again checked, even though scales have been sealed previously. Also, the scales should be checked after an extended rainy period because uneven settlement could cause the scales to bind or cause other inaccuracies.

The engineer should personally watch the marking and setting of scale weights, after the batch weights from each bin have been decided upon, to be sure the correct weight is actually being "pulled" at the proper time. Daily checks should then be made to be sure the settings remain in the correct place and that the batch weight procedure is right. An incorrect scale setting can cause the entire batch to be out of specifications. The sequence of weighing from each bin must be strictly observed and all scale settings correct to help prevent specification violations.

In some batch plants the scales are automatically operated and are electronically connected with the batching equipment so that the scale weights are automatically verified when the correct proportions of material have been weighed.

Inaccurate asphalt content can become one of the primary causes for failures in asphalt pavements and in many cases, the cause of failure can be traced through inaccurate asphalt scales. Asphalt scales must be checked daily to assure that they zero properly, that levers and knife edges can move and do move freely and that drag, friction, or binding is eliminated on the lever system. Asphalt or dust can build up on the knife edges in the lever system, or corrosion can dull the knife edges causing scale malfunction. Each scale should be equipped with a quick adjustment to zero to compensate for accumulations of dust or asphalt.

H. Asphalt Storage Tanks

Asphalt storage tanks provide separate storage for different asphalt materials and are equipped with devices for heating asphalt. Separate storage tanks must be provided when different grades of asphalt material are being used or are intended to be used on the project. This separation will prevent the possibility of contamination between grades. Storage tanks must be thoroughly cleaned and inspected before asphalt is introduced into them and always inspected when a different grade of asphalt is to be used, since some asphalts may be incompatible when blended.

Asphalt storage tanks are to have a positive means of measuring the quantity contained. Measurement can be by guage, calibrated rod or float. It is suggested that the tank be calibrated so that quantities determined from tank stabbings can be compared with quantities determined from theoretical batch weights or mix proportions and the platform scale sheets. One method for calibrating the storage tanks is to use a tanker equipped to transfer the asphalt through a positive displacement action asphalt pump and meter. Calibrations should be made at 100 gallon intervals and the engineer should be sure the supply line is below the surface of the asphalt to prevent excess splashing which may cause false readings or markings.

The asphalt in this storage system ie. storage tank transfer lines, pumps, feed lines etc. is to be heated by heating coils, steam coils or electricity so that no flame will contact the heating tanks. Heating is required to maintain the asphalt at the correct temperature.

The return lines discharging into the storage tanks must have the discharge end below the asphalt surface at all times to prevent oxidation and hardening of the asphalt. Swing lines quick disconnect couplings, and bleeder valves are not recommended as facilities for draining the asphalt lines because of the hazards involved. Rather, two or three vertical slots should be cut in the return line above the high surface level of the stored asphalt to facilitate draining lines.

I. Pugmill Mixer

After the hot aggregates leave the storage bins and are correctly proportioned they are introduced into the pugmill for mixing with the asphalt. The main part of the pugmill mixer consists of paddle tips, paddle shanks, spraybar, liners, shafts, discharge gate and heated jacket. Efficient mixing of the aggregates with the asphalt cement is dependent on many factors such as the shape of the paddle tips, speed of the mixing shafts, length of mixing time, temperature of the materials, quantity of material in the mixer and the clearance between paddle tips and the liner plates. Paddle tips and liner plates are subjected to continuous wearing action which in time can produce an excessive clearance between the tip and the liner plate. When excessive clearance does exist (generally more than 3/4"), the materials will be improperly mixed and the paddle tips or liner plates or both are to be replaced.

Mixers of batch plants and continuous flow plants accomplish the same purpose, but do so by variation in the arrangement of the paddle tips. Materials are dumped into the center of the batch mixer where special paddle tip arrangements produce an end to center mixing or figure eight mixing pattern, whereas in the continuous flow plant the pugmill accepts materials in one end and discharges out the other, by having paddle tip arrangements set to transport the materials to the discharge end as continuous mixing is accomplished.

The pugmill mixer on batch plants is to be equipped with an automatic timing device which automatically limits the dry mixing or wet mixing periods to the minimum time required by specifications. A time lock device is required by the specifications for the purpose of assuring minimum mixing time, both dry and wet. The device will lock the asphalt bucket throughout the dry mix time and will lock the mixer gate throughout the dry and the wet mix time. The time lock device will lock the weigh box gate after material is discharged into the mixer and keep it locked until the mixer gate closes when the cycle is completed. The inspector should check the timing occasionally to assure himself that no changes have been made without his knowledge. The inspector can require, if he so wishes, that the timer be locked and the key given to him.

Dry mixing time is the interval of time between the closing of the weigh box and the start of the discharge of the asphalt, whereas, wet mix time begins when the asphalt is first spread on the aggregate and ends when the mixture completes its discharge from the mixing unit. The above definition of mixing time applies to pugmill on batch plants. When continuous flow plants are used, the mixing time is equal to pugmill dead capacity in pounds, divided by pugmill output in pounds per second. Mixing time is not to be less than 30 seconds, no matter whether a batch type pugmill is used or continuous flow pugmill is used, the asphalt and aggregate mixture is to be homogenous with all of the asphalt particles uniformly coated with the correct quantity of asphalt.

The weight of any batch is not to exceed the rate capacity of the mixer as shown on the mixer name plate, nor is the production rate of a continuous flow plant to exceed the manufacturers rated capacity for that plant. The minimum allowable production rate for either plant is 100 tons per hour. Plants of a smaller capacity may be permitted for some types of urban work or where the lower production rate is efficient and acceptable.

J. Scales

The contractor is to furnish platform scales which are satisfactory to the engineer and of a size that will weigh a truck in one complete unbroken weighing operation. Truck-trailer units, too long for the scale, may be used, if the loaded unit can be weighed separate from the truck in one operation. The engineer can determine if the scales are satsifactory by having them tested and sealed by the Division Materials personnel. Frequent checks should be made during the course of production to assure that the scales are continuing to provide accurate weights. The contractor must have on hand ten 50 pound certified weights for testing the platform scale.

K. Mix Proportioning

The Helena Materials Division develops a mix design based on test results and the information furnished to them concerning the aggregates produced. The resultant mix design submitted to the field is intended as a firm guide. However, it may be necessary to make adjustments in the proportions of aggregates or asphalt content in order to make the most effective use of available materials. The plant inspector is required to make screen analysis of the aggregates from each bin and calculate the batch weights (or the gate openings and pump sprocket settings for a continuous mix plant) so the mixture will duplicate or closely approximate the recommended mix design.

1. Aggregate Proportioning for Batch Plants

Batch weight proportions are to be discussed with the contractor and the size of the batch determined with his cooperation. Batch plant ratings are usually stated on a plate attached to the side of the pugmill or plant which indicates the size of the batch that can be properly mixed. Primarily, the size of the batch consistent with the established hourly plant production rate. After the size of the batch has been determined, the hot bins should be completely emptied, the screening unit checked and the cold feeders, dryer and screening plant operated at the full operating rate for approximately three to five minutes. During this operation interval, the units should be carefully and continuously inspected. After the operation and production has been deemed satisfactory, materials may be drawn from each bin, carefully weighed and the total weight of the materials in each bin recorded. Representative samples should also be taken from each bin and a sieve analysis performed as an aid in proportioning. The following is an example of how to determine the proportions of bin materials, mineral filler and asphalt cement content on a three bin split batch plant.

Batch weight = 4000 lbs.
Percentage of Asphalt Cement to be added 6%
Pounds of dry aggregate = $\frac{4000}{100 \text{ (Agg.)} + 6.0 \text{ (asphalt)}}$ =3774 lbs.

Pounds of dry aggregate without mineral filler (1%)
3774 x 0.99 =3736 lbs.

A total of 3736 lbs. of dry aggregates are to be drawn from the bins as follows:

BIN		% OF TOTAL		LBS. PER BATCH
Course	-3/4 + 3/8	.20 x 3736	=	747 lbs.
Intermediate	-3/8 + #4	.30 x 3736	=	1121 lbs.
Fine	-4#	.50 x 3736	=	1868 lbs.
	TOTAL			3736 lbs.
Plus mineral filler added @ 1% x 3774			=	38 lbs.
	TOTAL DRY BATCH WEIGHT			3774 lbs.
To this dry batch weight is added 226 lbs. of asphalt (.06 x 3774)			=	226 lbs.
	TOTAL WEIGHT OF MIX			4000 lbs.

A trial run, similar to the above example may be used to determine the sizes going into each bin and the proportions to draw from each bin after general plant operation is deemed satisfactory. The combined aggregate gradation obtained by computing the various aggregate materials in individual bins, mineral filler and the percentages as outlined above, should check the gradation established by job mix formula, within the allowable tolerance. If the combined aggregate gradation does not check within the allowable tolerances, it will be necessary to repeat the trial run and weighing procedure or to compute revised proportions based on the gradation of the materials in each bin. Failure to check the combined gradation might indicate that materials in the cold feed were outside gradation as used in computing the job mix formula, or that they were improperly fed. Also, the cold feed calibration may not be reliable. Determine the reason why combined gradation and job mix formula do not agree and make corrections or adjustments.

2. Aggregate Proportion for Continuous Mix Plants

The functions of the continuous mix plant and the batch mix plant are essentially the same up to the point of discharge from the graded aggregate bins. The separate sizes of aggregates are proportioned in continuous mix plants through adjustable gates on the feeder mechanism of the gradation unit. The feeder gates on each bin can be moved upward or downward as needed to allow the right quantity of material through the gate opening. The asphalt and aggregate are introduced into the pug mixer continuously and the mix is discharged continuously. The specifications require that certain coordinated interlocking features be incorporated into each continuous mixing plant. The devices that feed asphalt and aggregate into the pug mixer are interlocked so that correct proportions are automatically maintained.

One revolution of the driving mechanism will deliver a pre-established quantity of material into the mixer during any chosen time interval. This quantity can be thought of as similar to a batch. The proportion of each ingredient can then be calculated much in the same manner as calculations would be made for a batch plant operation.

Some continuous mixing plants are equipped with signal systems and sampling or calibration hoppers, that provide automatic diversion of aggregate into weighing containers. This automation greatly aids in calibrating the continuous flow plant. However, automatic provisions may not exist for diverting aggregate into weighing buckets. It may be necessary to divert aggregate from each bin separately into trucks and then determine the discharge rate for each gate opening to calibrate the plant. The discharge rate must be held uniform during the calibration process to insure that the conditions encountered during calibration will truly represent conditions expected during plant operation. Screens that transmit vibration to the hot bins, should be operated while calibrating the plant to insure uniformity. Some variations that may exist to discourage uniformity are:

(a) Vibration of the Plant.
(b) Rotational speed of the feeders.
(c) Depth of the feed.
(d) Head or weight of the aggregate above the feeders in the bins.
(e) The size and shape of aggregate, and aggregate surface characteristics, as well as moisture or sweating in the bins.

As many of these and other unmentioned variables as possible should be eliminated during the calibration process.

The manufacturers specifications for plant operation, calibration of the hot bin feeders, mineral filler feed and calibration of the asphalt pump are to be thoroughly reviewed by the contractor and engineer, before any calibration procedure is begun. Asphalt should be pumped through the plant under normal operating pressure and the cold aggregate feeder, dryer, dust collector, screen deck and other features should be operated for a short period of time to eliminate the usual start up variations.

The aggregate feeder mechanism will draw material from all bins at the same time. This requires separate test buckets to catch the flow of material from each bin. Therefore, to calibrate each feeder gate should be set at the same opening and the revolution counter-read, the plant operated and a sample taken of material flowing from

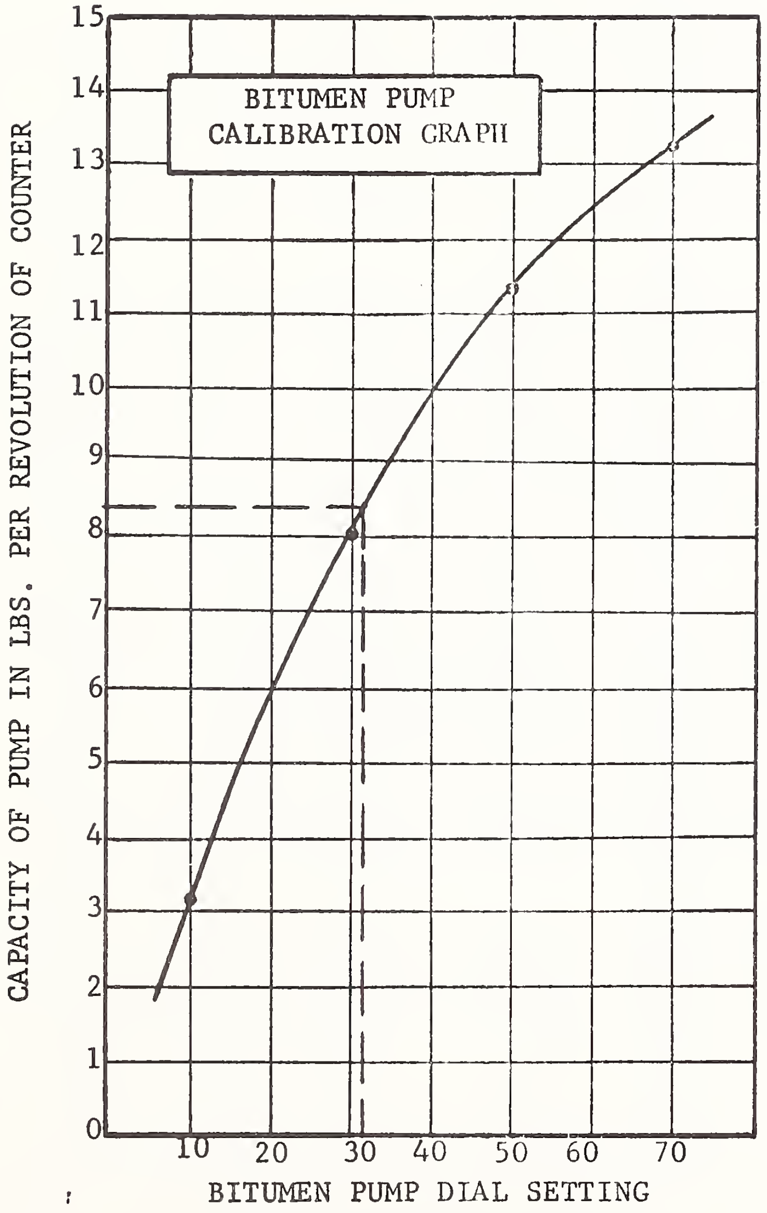

BITUMEN PUMP
CALIBRATION GRAPH
CAPACITY OF PUMP IN LBS. PER REVOLUTION OF COUNTER
BITUMEN PUMP DIAL SETTING
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
10
20
30
40
50
60
70

FIGURE IV-6

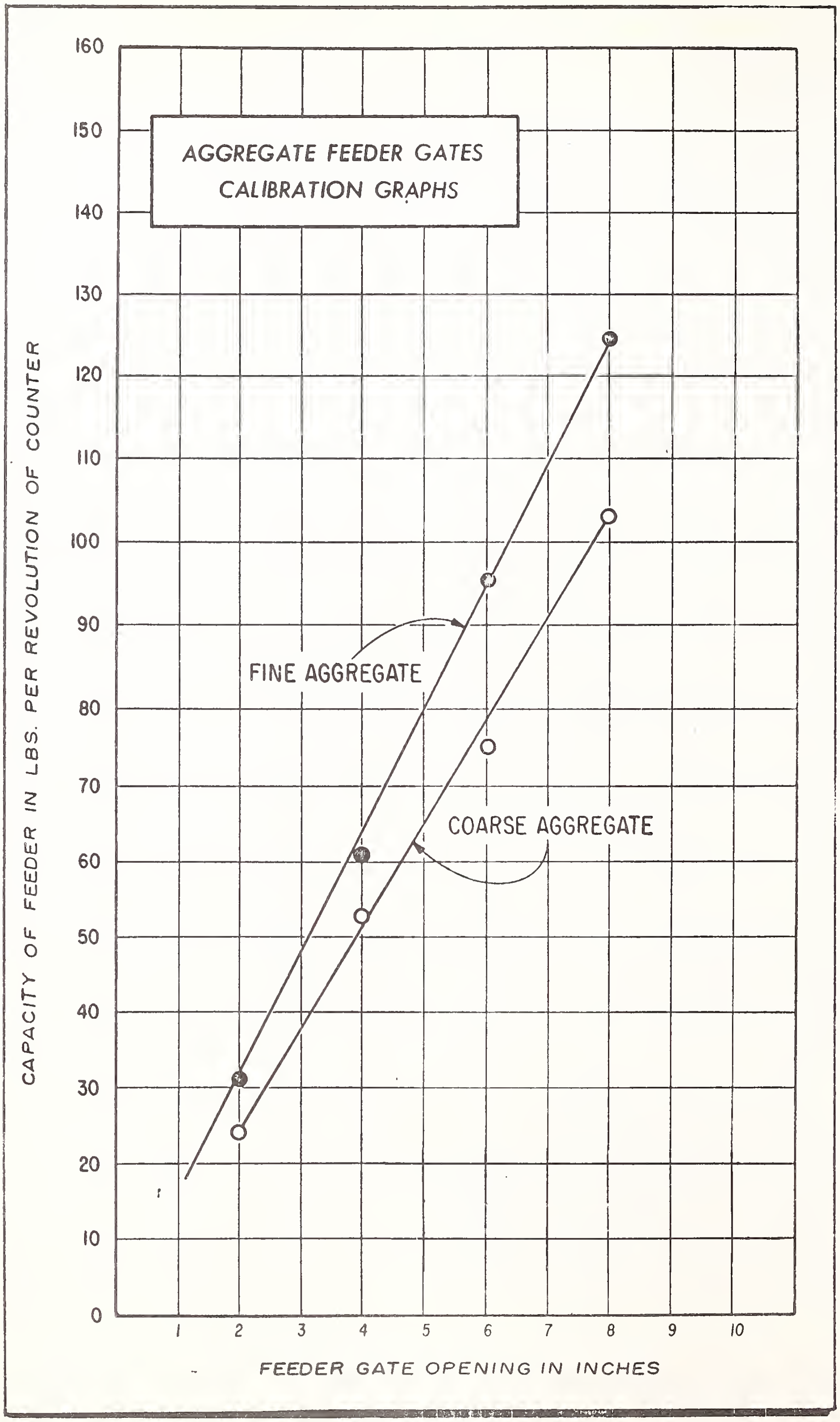

AGGREGATE FEEDER GATES
CALIBRATION GRAPHS
FINE AGGREGATE
COARSE AGGREGATE
CAPACITY OF FEEDER IN LBS. PER REVOLUTION OF COUNTER
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
FEEDER GATE OPENING IN INCHES

FIGURE IV-7

each bin. The plant should be stopped and again the revolution counter-read. Record the difference between initial and final readings of the revolution counter as well as the net weight of the material sample from each bin. This procedure should be repeated until the results of at least four different gate openings have been checked with the results of sample testing from the four different gates. Openings can then be plotted on a calibration graph for the continuous mix plant.

The number of pounds of aggregate delivered from each feeder for a single revolution of the feeder mechanism can be determined as follows:

> Divide the net weight of the aggregate by the numerical difference between the revolution counter readings at the start and the end of the test.
>
> The mineral filler feed can be calibrated in the same manner as calibrating the hot bin and feeders and the operation repeated until at least three different settings have been obtained. The aggregate hot bins should be empty and the mineral filler hopper sufficiently full to provide a uniform discharge throughout the length of the test. The revolution counter is read, the plant operated and samples obtained. Then the plant stopped. After the plant has been stopped the revolution counter should again be read and the material weighed as was done for calibrating the aggregate feed. Records should be made of observations taken of the revolution counter, the tare weight of the bucket and computations made to determine the net weight of the material obtained. After computations have been made to determine the net weight at different arm settings of the mineral filler feeder, this data should be plotted on a calibration graph. The graph will provide an accurate means of determining the proper settings at different production rates.

The asphalt pump must also be calibrated to determine the pounds of asphalt obtained for each revolution of the feeder mechanism. Before the calibration is begun the plant should be started and the asphalt circulated through the lines in the pump to obtain normal operating pressure and assure that operating temperatures will be the same as those during calibration. Pressure gauges should be placed on both sides of the pump to indicate any abrupt changes that may affect the quantity of asphalt pumped through it. A positive displacement pump, in good condition, will deliver a constant volume per revolution so the only variable should be pump settings or gears used. The revolution counter should be read at the start and the end of calibration, during which approximately 50 gallons of asphalt should be pumped into a tared sample container at the operating pressure. The number of revolutions to discharge this exact weight of asphalt will then be known, and can be compared with manufacturers calibrating table of discharge for the various gear combinations.

Repeated tests should be made with each gear combination to insure an accurate determination of the pump discharge rate. The first test should be conducted with a gear that will deliver the approximate quantity of asphalt needed, then other tests can be made with different gear combinations. The calibration should be repeated at frequent intervals to insure an accurate control of asphalt delivered to the mix. Once the plant has started production, accuracy of the asphalt pump can further be checked against quantities used by comparing asphalt deliveries and tank "stabbings".

As an example, assume that six percent of 85-100 penetration asphalt cement with a specific gravity of 1.005 is to be used and that the plant operating rate of combined aggregate each hour is 154 tons, or 5,133 pounds of combined aggregate each minute. The asphalt cement content for each minute must be determined then from this quantity of combined aggregate and is 0.06 x 5133 = 308 pounds of asphalt cement per minute. The pounds of asphalt cement per minute should then be adjusted to gallons per minute at 60 degrees and then to pounds per minute at the operating temperature. For purposes of this explanation, assume operating temperature to be 275 degrees. This conversion is as follows:

1.005 x 8.328 = 8.3696 lbs. per gallon at 60 degrees, then
8.3696 lbs. x .9280 = 7.767 lbs. per gallon at 275 degrees, then
308 lbs. of asphalt cement divided by 7.767 lbs. = 39.65 gallons per minute at 275 degrees.

An asphalt plant that is equipped with an adjustable pump and meter can be set to pump this rate of asphalt per minute then this quantity of asphalt is checked by the asphalt meter.

However, some asphalt plants are equipped with a pump that can be adjusted only by a change in the sprockets. Then a value in gallons per minute, which is nearest the quantity just computed, must be obtained. The manufacturers plate on the pump should be checked to make certain that the chart being used is correct for that pump. Assume in selecting the correct pump sprocket and driver sprocket combination, that the closest value obtained to the computed gallons per minute is 41.6 gallons per revolution. Since this asphalt pump rate is slightly more than the desired rate, a small adjustment in the output of the plant will be necessary in order to maintain the asphalt content at 6%. The adjustment is as follows:

41.60 gallons x 7.767 lbs. per gallon at 275 degrees = 323.1 lbs.
then, 323.1 lbs. divided by 0.06 = 5385 lbs. of aggregate per minute, or 161.5 tons of aggregate per hour.

Adjustments would then have to be made to set the cold aggregate and mineral filler feeders to feed 161.5 tons of combined aggregate each hour and the correct sprocket combination chosen to feed 41.60 gallons of asphalt cement each minute.

L. Plant Inspectors Check List

Asphalt hot plant inspection should be thought of as an overall operation of material flow, from the storage area through the dryer, dust collector, screening, into the pug mixer and out to the trucks for transport to the paving site. Each point in the materials flow can then be inspected for specification compliance, for correct operation, and its influence on other phases of the plant operation.

Before any plant inspection, can begin, the plant inspector must have been provided with all of the test facilities needed. During the course of the work, the following check list has been provided as a guide which covers most of the important details for inspecting asphalt concrete plant operations.

1. Material Handling and Storage.

   (a) The storage area, storage pile, or piles should be satisfactory. Segregation should be controlled. Separately sized piles should not intermingle and the stored aggregate should be within the specification limits.

   (b) The mineral filler feeder should be checked for uniform introduction of the mineral filler. The mineral filler should be dry.

2. Dryer and Dust Collector.

   (a) Both dryer and dust collector must be in proper working order and comply with specifications.

   (b) The pyrometer or heat indicating device should be checked for accuracy to assure that the aggregates are being dried at the correct temperature.

   (c) Check the dust collector for its ability to waste or uniformly feed a desired amount of collected fines back into the aggregate flow.

3. Hot Screens and Hot Bins.

   (a) The screening capacity should be large enough to handle the maximum feed from the dryer and be in excess of the full capacity of the mixing unit.

   (b) The hot bin partitions should be sturdy and free from holes. The hot bins should have overflow bins that are actually working.

   (c) Platforms for sampling, sampling devices and general access for sampling must be safe, accessible and adequate.

4. Batch Plant.

   (a) All of the batch scales must comply with specifications regarding capacity and sensitivity.

   (b) The mixer parts must be in good condition and proper adjustment to provide correct mixing within the time limit specified.

   (c) Is the correct batch size being mixed and is the mixing being performed within the correct temperature range?

5. Continuous Mix Plant.

   (a) Are the aggregate and asphalt feed interlocked? Have they been calibrated?

   (b) Are all mixer parts in good condition and adjustment to produce a mixture within the correct temperature range?

   (c) Is the overflow dam set at the correct height?

6. Sampling and Testing.

   (a) Are an adequate number of samples being taken and are those samples representative?

   (b) Are all tests being performed according to the Montana Test method?

   (c) Is the testing frequency as specified and are test results available soon enough to be effective to control production?

   (d) Is the contractor made aware of test results?

   (e) Is the daily plant mix form being kept up to date and are daily dairy entries being made of the plant operation?

7. Safety.

   (a) Be certain that no open fires are allowed around asphalt or fuel oil storage tanks.

   (b) All pulleys, belts or sprockets and other drive mechanisms should be covered and protected or reported to Safety.

   (c) Check the steam or oil jackets on asphalt distributor lines for any leaks.

   (d) A "Panic Button" or switch that will stop all operations is to be provided in the event of an emergency. Do plant workmen know the location of this switch? Is the switch easily accessible?

M. DAILY PLANT MIX REPORT

Pages 47-19A through 47-19D, show examples of a "Daily Plant Mix" form and its accompanying gradation work sheets for guidance in completing these forms.

Each project is a separate job having different problems that need different solutions than last summer's job or the paving coming up next summer. The "remarks" spaces at the bottom of each Daily Plant Mix Form has been made especially large in order that inspectors could write their description of the job happenings on a daily basis. Then, when troubles develop or when the Materials Engineer writes his job history, a record of past events will exist. This record can be extremely valuable in reconstructing paving activities while attempting to resolve problems that come to light after the work is done.

Each item of the heading must be completely filled in, i.e. Project-- Location-- Report No.--, etc.

The plant setting and control values that have been used for each days run must be placed in the spaces provided. If no changes have been made, then a brief note referring to the report number that shows the values being used is all that is needed. If a change has been made, the new values are to be shown for the day that changes were made.

Other information must be shown, where applicable, to complete the form.

Lab No. 98-C Rev. 3-68

47-19A

DAILY PLANT MIX FORM

MONTANA STATE HIGHWAY COMMISSION

Project I 15-5(23)100 U-1
Location Happy Creek - South
Contractor Crook Brothers Construction Company
Type of Plant Baldwin-Lima-Hamilton Batch Plant

Report No. 1
Date 8/31/68
Type of Mix III
Bitum. Matl. 100-120 Pen.

CONTINUOUS PLANT SETTINGS AND CONTROL

Spot Checks: % Asph. & Time: See First Report
Assumed Capacity (T.P.H.)
Aggreg. Gate Settings
Agg.-Lbs./Min. at Ass. Cap:
Pump Setting (Gal./Min.):
Pump Size:
Sprockets

TEMPERATURES

Time	9:30 AM	10:30	11:30	12:30	1:30PM	2:30	3:30	5:30			
	Temp.	Temp.	Temp.	Temp.	Temp.	Temp.	Temp.	Temp.	Temp.	Temp.	Temp.
Aggregate	300°	300°	300°	300°	300°	300°	295°	300°			
Asphalt	275°	275°	275°	275°	275°	275°	270°	275°			
Mix	275°	275°	275°	270°	290°	275°	270°	270°			

MIX USED

NO. OF COURSES 2 TOTAL THICKNESS .35

COURSE	TONS USED			PLACED			
	Today	Previous	To Date	Station to Station	Lane & Width	Sq. Yds.	Yield Lbs./Sq. Yds.
Apprs.							
Leveling				1624+18.5/1667+54	6 5 11' 12'	Tapered Depth & Width	
1st Course	1189.20	0.0	1189.20	1624+18.5/1638+00	4 & 3 8'	2460	230.500
2nd Course							
Total	1189.20	0.0	1189.20				

ASPHALT USED

Supplier Phillips Pet. Co.
Cert. Nos. 106402-2 6 & 7
Sp. Gr. 1.019 Wt. (Lbs./Gal.) 8.490

	Today	Previous	To Date
Gals.	16,350	0	16,350

% Asph. for Day 6.2%

SAMPLES FOR EXTRACTION

No.	Station	Course	Lane
1	1635+75	1	6
2	1664+50	1	5

PLANT HOURS

Time Start:	7:00 AM
Time Stop:	6:00 PM
Gross Time:	11 Hours
Time Delay:	5 Hours
Net Time:	6 Hours
Avg. Hourly Prod.:	198 Ton

MINERAL FILLER USED: Today ____ Tons Previous ____ Tons Total to date ____ Tons
Type ____ Brand ____ Supplier ____
WEATHER: Condition Clear and Calm Temperature A.M. 60° P.M. 75°
Remarks: Due to tapers and connection 5 hour time delay. Test numbers 2 and 4 were low on 10M material. The contractor will adjust the screens on fine bin tonight to produce more - 10M material in this bin. A finer screen will be used.

Plant Inspector

Project No. I 15-5 (23) 100 U1

Daily Plant Mix Report No. 1

WORK SHEET FOR AGGREGATE GRADATIONS

Date 8-31-68

(To Accompany Daily Plant Mix Form)

No. 1

PIT LAB. Nos. 215697-712

Sieve Size	Fine % Used 40		Intermediate % Used 34		Intermediate % Used		Coarse % Used 26		Mineral Filler % Used		Combined Grad.	Job Mix	Spec.
	Total % Pass	% of Total	Total % Pass	% of Total	Total % Pass	% of Total	Total % Pass	% of Total	Total % Pass	% of Total			
¾"	100	40	100	34			100	26			100	100	100
½"	100	40	100	34			51.4	13.4			87.4	87	80-100
⅜"	100	40	97.7	33.2			4.4	1.1			74	75	70-90
¼"													
#4	100	40	43.1	14.7			.9	.2			55	55	50-70
#10	89	35.6	9.0	3.1			.2	0			39	40	33-47
#40	53	21.2	2.2	0.7			.2	0			22	21	15-25
#80	25	10.0	1.7	0.6			.1	0			11	13	9-18
#200	14	5.6	1.3	0.4			.1	0			6.0	6.5	4-10

LL. ______ PI ______ % Moist. ______ % Fract. 74% Sta. 1624+18.5 to Sta. 1643+24.6

No. 2

	% Used 40		% Used 34		% Used		% Used 26		% Used				
¾"	100	40	100	34			100	26			100	100	100
½"	100	40	100	34			47.6	12.4			86	87	80-100
⅜"	100	40	97.2	33			5.2	1.4			74	75	70-90
¼"													
#4	99.2	39.7	38.5	13.1			0.8	.2			53	55	50-70
#10	77	30.8	12.7	4.3			0.7	.2			34	40	33-47
#40	42	16.8	4.6	1.5			0.4	.1			18	21	15-25
#80	21	8.4	2.9	1.0			0.3	.1			10	13	9-18
#200	15	6.0	2.0	.7			0	0			6.7	6.5	4-10

LL. NP PI NP % Moist. ______ % Fract. 78% Sta. 1643+24.6 to Sta. 1654+34 Eq.

TAPER TO STA.
1667+54.3

Project No. I 15-5(23) 100 U1

Daily Plant Mix Report No. 1

WORK SHEET FOR AGGREGATE GRADATIONS

Date 8-31-68

(To Accompany Daily Plant Mix Form)

No. 3

Sieve Size	Fine % Used 40		Intermediate % Used 34		Intermediate % Used		Coarse % Used 26		Mineral Filler % Used		Combined Grad.	Job Mix	Spec.
	Total % Pass	% of Total	Total % Pass	% of Total	Total % Pass	% of Total	Total % Pass	% of Total	Total % Pass	% of Total			
¾"	100	40	100	34			100	26			100	100	
½"	100	40	100	34			49.2	12.8			86	87	
⅜"	100	40	98.1	33.4			6.4	1.7			75	75	
¼"													
#4	99.6	39.8	48.1	16.4			.7	.2			56	55	
#10	82.0	33.3	12.0	4.1			.5	.1			38	40	
#40	60.8	24.3	1.4	.5			.1	.0			25	21	
#80	33.9	13.6	0.5	.2			.0	.0			14	13	
#200	18.9	7.6	0.0	.0			.0	.0			7.6	6.5	

LL. PL % Moist. % Fract. 73% Sta. Same as test #2 to Sta.

No.

	% Used		% Used		% Used		% Used		% Used				
¾"													
½"													
⅜"													
¼"													
#4													
#10													
#40													
#80													
#200													

NP PL NP % Moist % Sta. to

Project No. I 15-5(23)100 U1

Daily Plant Mix Report No. 1

W K SHEET OR AGGREGATE GRADATI

Date 8-31-

(To Accompany Daily Plant Mix Form)

No. MOISTURE #1

Sieve Size	Fine % Used 40		Intermediate % Used 34		Intermediate % Used		Coarse % Used 26		Mineral Filler % Used		Combined Grad.	Job Mix	Spec.
	Total % Pass	% of Total	Total % Pass	% of Total	Total % Pass	% of Total	Total % Pass	% of Total	Total % Pass	% of Total			
	MOISTURE		TEST ON	3/4"	PLANT	MIX (BIT.	SURF.)	AGGREGATES					
3/4"	AGGREGATE SIZE				FRACTION OF JOB MIX					MOISTURE CONTENT			
1/2"	3/4	+0	3/8"			.26		X		0.10	=		0.026
3/8"													
1/4"	3/8"	+0	#10			.34		X		0.008	=		0.003
#4													
#10	PASSING		#10			.40		X		0.005	=		0.002
#40													
#80						COMPOSITE	MOISTURE		CONTENT		=		0.031
#200													

LL. PI % Moist. % Fract. Sta. to Sta.

Sieve Size	% Used 40		% Used 34		% Used		% Used 26		% Used			No. 4	
3/4"	100	40	100	34			100	26			100	100	
1/2"	100	40	100	34			50.6	13.2			87	87	
3/8"	100	40	98.7	33.6			6.0	1.6			75	75	
1/4"													
#4	98.1	39.2	46.6	15.8			0.5	0.1			55	55	
#10	70.6	28.2	12.6	4.3			0.4	0.1			(33)	40	
#40	50.0	20.0	5.1	1.7			0.3	0.1			22	21	
#80	17.7	7.1	4.7	1.6			0.0	0.0			9.0	13	
#200	12.8	5.1	3.7	1.3			0.0	0.0			6.4	6.5	

LL. NP PI NP % Moist. % Fract. 77% Sta. 1643+24.6 to Sta. 1654+34 Eq.

TAPER TO STA. 1667+54.3

THIS TEST FAILED. THE RESULTS WERE APPROX. THE SAME AS TEST #2, LOW ON -10M MATERIAL. THE CONTRACTOR WILL CHANGE SCREENS IN THE FINE BIN.

47.05 Paving Operation and Inspection

A. General

All of the intricate details of plant inspection, control and operation to produce a satisfactory mix can be largely wasted if the placement and compaction of the mix are not properly accomplished. The two functions, Plant Operation and Paving Operation, must result in an intimately combined and coordinated team effort where neither function is more important than the other, yet each operation is absolutely essential in producing a strong, durable and smooth pavement.

It is suggested that the road inspector review the various manufacturer's manuals on paver operation and adjustment and study the special provisions and specifications for paving and compaction. The Asphalt Institute's Paving Manual provides a great deal of useful guidance on all phases of the paving operation and should be used as a reference manual. However, the inspector should always keep in mind that the contractor's operation, equipment usage, temperature ranges and general paving procedure must all be in accordance with, or comply with the Montana specifications. Montana specifications must take precedent over any other manuals, brochures or reference guides.

Good preparation would involve equipment inspection, determining the paving schedule and paving widths. A thorough check of plans and specifications for that particular job and general discussions between the Engineer and the contractor will help establish control at the start of the job. In this way, any corrections that are needed can be made before paving begins and procedures can be set down for correcting or changing as is needed during the course of the work.

B. Traffic Control

Engineers whose projects are conducted out of the way of traffic are quite fortunate, for on these projects, the majority of attention can be placed on the paving operation itself. Traffic control through or around a paving area must be thoroughly discussed with the contractor before the start of the operation. The use of flagmen, pilot cars and warning signs, or the placement of detours are to satisfy continuous, but safe traffic movements and provide safety for workmen with the least interruption to the paving schedule.

Traffic, carried on an unpaved shoulder during the paving operation, can cause blowing dust to become a traffic hazard. Similarly, on pavement widening projects, the open trench is an unusually dangerous traffic hazard. Paving areas that are not particularly dangerous during the daylight hours may require special treatment during the hours of darkness. The decisions whether to use flagmen and pilot cars, barricades, pavement edge delineators, warning signs, flasher lights or similar approved traffic control devices must be decided in order to protect and guide the traffic. Special hazards require special treatment and the placement of guidance devices for unusual situations should receive the traffic engineer's review, if there is the least doubt about their adequacy.

All barricades, warning signs and other traffic control equipment must be in place and readily visible before any paving can be allowed.

C. Equipment Inspection

1. General

Each piece of the contractor's paving equipment and his trucks and rollers are to be checked for their condition, power, obvious defects and too much wear in bearings or linkages. Deficiencies in the condition of various pieces of equipment if discovered and corrected before paving starts, will help in avoiding delays caused by equipment malfunction later.

2. Pavers

The details of the various adjustments to be made on each type of paver are shown in the particular manufacturer's handbook, Pioneer, Barber Green, etc. These handbooks should be referred to when making any precise adjustments, but the inspector should familiarize himself with the mechanical features on the type of paver being used so an intelligent appraisal of the condition and adjustment of the machine may be made. Some general features to be checked on the various paving machines are as follows:

(a) Does the paver meet specification requirement?

(b) Is the engine governor operating properly and does the engine run smoothly without missing?

(c) Check the slat feeders, hopper gates and spreader screws for excessive wear. Are they in proper adjustment?

(d) Track type machines must have the track linkage correctly adjusted and the tracks and pins checked for excessive wear.

(e) Are all tires on the pneumatic tired machines inflated uniformly and at the correct pressures? Check the chain drive for correct adjustment and excessive wear.

(f) Tamper bars are to be free of excessive wear and have their stroke correctly adjusted.

(g) Are the tamper bars correctly adjusted for clearance between the back of the bar and the nose of the screed plate.

(h) Is the oscillating screed in proper position with respect to the vibrating compactor?

(i) Check the screed plates for excessive wear, proper crown and tilt adjustment. Does the screed heater work properly? Any screed extensions used are to be in the same true plane and made flush with the screed bottom. The surface of the screed plates must be true and in good condition. Check the screed vibrators for their condition and adjustment.

(j) Are the mat thickness and crown controls in good adjustment and good condition?

(k) Are the automatic grade controls functioning properly.

3. Rollers

All rollers must meet the specification requirements. Steel wheel rollers must be capable of rolling in a true plane with the wheels free of flat spots, ridges or grooves. The steering and drive mechanism must be tight, having no backlash. The motor and driving transmission should have no excessive oil leaks.

Pneumatic tired rollers are to be equipped with smooth tires of equal size, same ply, and be equally inflated. A minimum contact pressure of 60 psi must be maintained except when the roller is used as a breakdown roller and tire pressure can be regulated while rolling. (air-on-the-run).

Vibratory rollers should have a minimum drum diameter of 48" and width of 60", and must be self-propelled and have a variable frequency adjustment from 1100-1500 V.P.M. The vibratory mechanism must be capable of being completely shut off when the roller is stopped or is about to stop.

Check each roller for its ability to start, stop and reverse smoothly. Are wheel bearings and king pins free of excessive wear? All rollers are to be equipped with cleaning devices and also have suitable means of wetting the rolling surface.

4. Trucks

Vehicles used to transport the asphalt mixture to the roadway are to be in good operating condition, capable of containing, transporting and dumping all of the asphalt mixture. Dumping, into the paver or windrow is to be a smooth operation done without spilling. Each truck used to haul asphalt mixture should be assigned a number before hauling begins. The truck beds should be sprayed with a light coating of an approved solution that will prevent the asphalt from adhering to the truck bed. The solution can be lime water, soap, detergent solution or a solution of other similar materials. The use of diesel fuel, gasoline or other oil that may cut the asphalt is not permitted.

Vehicles must have smooth metal beds, not cause segregation, be free from excessive oil leaks and be in a mechanical condition that will not cause delays to the work. Insulated truck beds may be required, or the load covered with a tarpaulin while in transit to prevent excessive loss of heat from the asphalt plant to the roadway. Also, it may be necessary to cover the asphalt load with a tarpaulin to prevent contamination by dust, or to eliminate rain from entering the mix.

The contractor should provide a sufficient number of hauling vehicles to provide a uniform quantity of mixture to the paver, thus, assuring a uniform and continuous paving operation.

5. Miscellaneous Equipment

The contractor must have available on the project, such miscellaneous tools as rakes, shovels, brooms or other small tools for use in making minor adjustments to the asphalt mixture.

D. Hauling Plant Mix

The mixture is hauled from the plant to the paving site where the inspector receives the weight ticket from the truck driver to account for the delivery of that load of material to the paving area. As each vehicle arrives at the paver, its load is to be inspected visually for any evidences of excessive moisture, segregation, slumping in the truck bed or visual evidence of excessive asphalt content. Evidence of an improper mix must be immediately brought to the contractor's attention. Unusable loads should be rejected, the plant inspector notified quickly and corrective action taken, if needed.

The asphalt mix temperature may drop excessively due to hauling delays, bunching of the trucks on the road, intermittent operation of the mixing plant, cooling of the mix while in transit, or spreading the materials too far in advance of the finishing machine. Adverse weather conditions could cause a drop in mix temperature. Correct temperature is necessary for adequate compaction.

A truck load of mixture may be rejected for cause, but before rejecting any load of mix, the inspector must be sure of his ground and not reject just to show his authority. A load of mix may be rejected for any of the following reasons which can usually be determined visually.

1. Temperature: Too hot or too cold when compared to the temerature viscosity mixing range for the asphalt type being used.
2. Asphalt: Too much, slumps the load or runs out of the truck bed. Too little results in no asphalt on rocks, very light color.
3. Too much moisture: Bubbles on the coarse aggregates and blisters behind the paver.
4. Segregation: Mostly coarse rock with hardly any fines or too many fines hardly any coarse rocks.
5. Non-uniform mixing: Many rocks not coated.

A fast means of communication should be established between the road inspector and the plant inspector in order to make corrections rapidly at the time they are needed. The frames of some hauling vehicle might contact the paving machine, or bear down on the paver when dumping into its hopper. This force causes ridges or depressions in the paved surface. Truck frames that either contact or bear upon the paving machine must be corrected or not permitted in the work.

E. Spreading

It will be the contractor's responsibility to establish the rate of spreading, but the engineer is to check this rate to insure the correct depth and yield. Quantity checks are to be done before the job begins so that any errors causing substantial over-runs or under-runs may be corrected or have proper adjustments made. The correct yield can be checked from the weight tickets, accumulated as the daily work progresses, and checked at noon, end of the day, or other delay periods during the course of the paving work.

Asphalt material may be windrowed on the road bed ahead of the paving machine, picked up by mechanical means and placed in the paver hopper or dumped directly into the paver hopper from the hauling vehicle. The latter method of delivering material to the paving machine is by far the most common practice in Montana, however, windrowing material ahead of the paving machine does have the advantage of permitting a more continuous operation of the paver. Some disadvantages also exist when using this method. For instance, material is windrowed too far in advance of the paver, the mix can cool too rapidly.

It is extremely important that paving machines are in good adjustment and that screed operators are experienced and capable. The manipulation of thickness controls is always held to a minimum for any successful paving operation. All adjustment devices should operate and their operation should be uniform and continuous. Screed and adjustment devices can operate properly but other undesirable variables can cause changes in the thickness of the layer without any change in the thickness control adjustment or handles. Such variables are: temperature, height, and quantity of material in front of the screed, weight of the screed, and forward speed of the paver.

All paving machines are basically designed to lay a uniform thickness, but can, through delayed action, provide a smoothing and leveling effect over small irregularities. Pavers are most effective when their operation is continuous. Starts and stops will increase surface irregularities.

Automatic grade control is required for all pavers except when used for irregular sections or sections where it is not practical such as road approaches, shoulders on concrete pavement, and the like. Manufacturers literature should be referred to for sensitivity, method of operation, adjustments, etc.

An automatic grade control unit, when operating properly, will divorce the screed from the upward or downward movement of the floating arms which attach the screed to the machine. This control is transferred to the unit equipped with a sensor element which travels in a rigidly set or traveling guideline. When this unit malfunctions, it tends to compound its own errors and should be immediately stopped, the pavement corrected and the malfunction located before proceeding. The paving inspector and the paving crew should be thoroughly familiar with the operation and the adjustment of pavers equipped with automatic grade control units.

Manually operated screeds demand expert use of the thickness control handles. Once adjusted they should be left alone to allow the machine to level small irregularities by itself through the use of the soft leveling delayed action principal. Screeds on one brand of paver may react much more rapidly than screeds on another brand. It is, therefore, possible to over control the screed on one machine and under control it on another, since it takes from one to eight turns of the adjusting handles on different pavers to raise the screed 1 inch.

Trucks should never be used to pull the paver, rather the dumping vehicle should be held against the roll of the paver to prevent bumping of the machine and spillage of the material in front of the paver. Any material that is spilled must be cleaned up to prevent the formation of a bump.

The speed of the paver should be regulated by plant production striving for a continuous operation. For instance, if the plant is producing 100 tons per hour, the paver's speed can be computed by knowind the mat thickness, its width and the weight per square foot of asphalt material being placed. Assume a mat thickness of 1½" and a material weight of 15.4 pounds per square foot and a lane width of 12 feet. The paver speed will have to be 18 feet per minute in order to equal the 100 tons per hour of production. Various other speeds may be easily determined to provide a continous paving operation. Paving machine operators who operate the paver faster than plant production will cause a jerky stop and go operation. Do not allow this. The ideal paver speed is that which will give a smooth nearly continuous process with a minimum of stops while waiting for trucks. If the paver is operated at an excessive rate of speed, because of high plant production rate, the contractor should correct the situation by slowing production or adding paving machines.

Some common difficulties encountered that can be traced to the improper paving operation or incorrect machine adjustment are listed below:

1. A wavy surface with short, choppy waves can be caused by poorly adjusted tracks or drive chains, the truck driver setting brakes too tight, or excessive paving machine speed.

2. A wavy surface with long waves can be caused by excessive variation in the quantity of mix carried in the auger box ahead of the tampers or screed, rolling too early, rolling

to fast, or over-controlling the screed.

3. Mix with an open surface can be caused by improper adjustment of the tamper bar, improper tamper bar speed, rough screed plate, or too much paving machine speed.

4. A varying surface texture may be caused by insufficient mixing, overmixing, overheating of the mix, segregation of the mix, or a worn or damaged screed plate.

5. Bleeding patches on the surface can be caused by too much asphalt, asphalt not uniformly mixed or excessive moisture in the mix.

   Excessive moisture in the mix is also apparent when small bubbles appear on the coarse rocks in the mix, the mix slumps in the truck beds, or bubbles or blisters appear immediately behind the paver.

6. Irregular rough spots in the pavement can be caused by rollers standing on the fresh surface, abrupt reversing of the roller, trucks backing into the paver or poor workmanship at transverse joints.

   The use of a motor grader in smoothing and spreading the mixture is permitted only in areas that are inaccessible to the paving machine, or for leveling and correcting irregularities in the existing surface before placing and the first full course of asphalt material.

F. Compacting the Mix

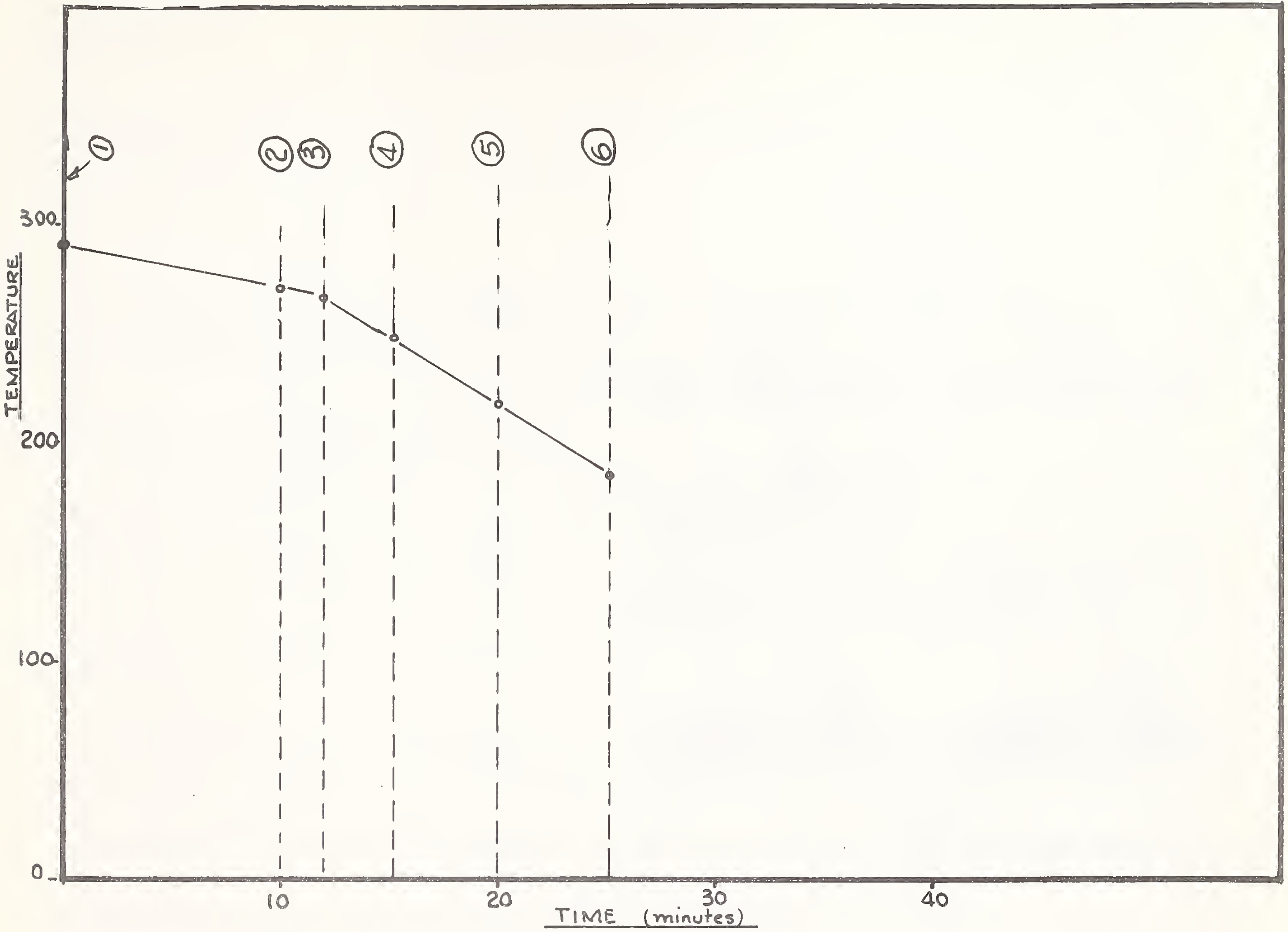
The Standard Specifications have set forth two rolling methods:

Compaction Method No. 1

Compaction method No. 1 consists of three recommended phases that can be changed to obtain the best result. These are the initial or breakdown rolling with a smooth steel wheeled roller, intermediate rolling with a self-propelled pneumatic tired roller then finish rolling with an approved steel wheel roller. Specifications show the method and number of passes required under each phase, so only the intermediate phase and vibrating rolling will be mentioned here.

Intermediate rolling must be done with a minimum of three complete coverages before the temperature of the mix reaches 160 degrees F. A rolling curve should be developed to help determine when rolling should be started and finished.

Increasing use has been made of vibratory steel wheeled rollers in compaction of asphaltic mixes. Under compaction Method No. 1, a steel wheel vibratory roller can be permitted if the engineer approves. It is conceivable that a vibratory roller can be used for the initial, inter-



① Temperature of the mix in the hauling vehicle at the plant.

② Temperature of the mix in the hauling vehicle at the paving site.

③ Temperature of the mix on the road immediately behind the paver & when breakdown rolling starts.

④ Temperature of the mix on the road at the point where intermediate rolling begins.

⑤ Temperature of the mix on the road at the point where final rolling begins.

⑥ Temperature of the mat at the point where final rolling is completed.

The engineer can generally predict the temperature to begin rolling and can know the longest time that rolling will still be effective, by making a plot of the rate at which the mat cools. This rolling curve can be established by taking the mix temperature at the following points: (At the plant, when delivered to the paving site and at the beginning of rolling just behind the paver and end of rolling) and plotting these temperatures vs. the time at which each temperature reading was taken.

Fig. IV-10A

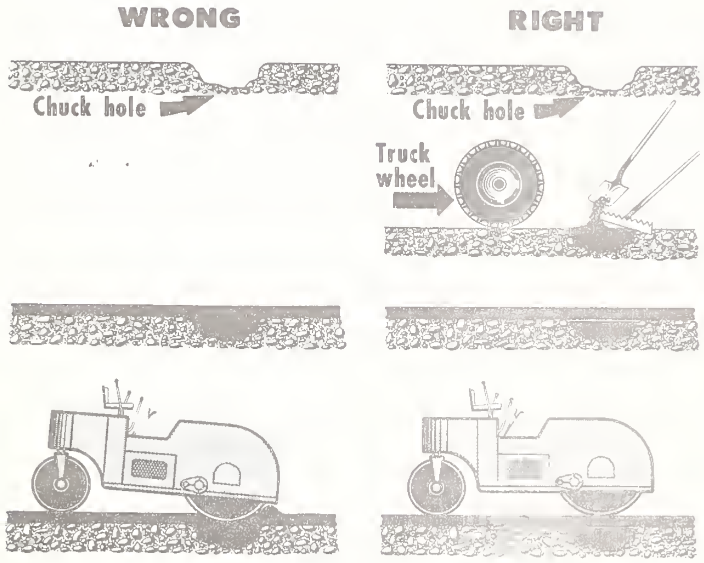
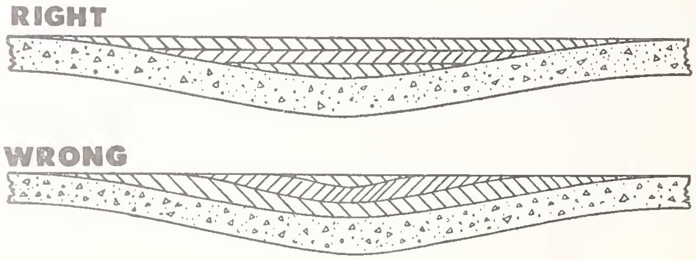


FIGURE 20

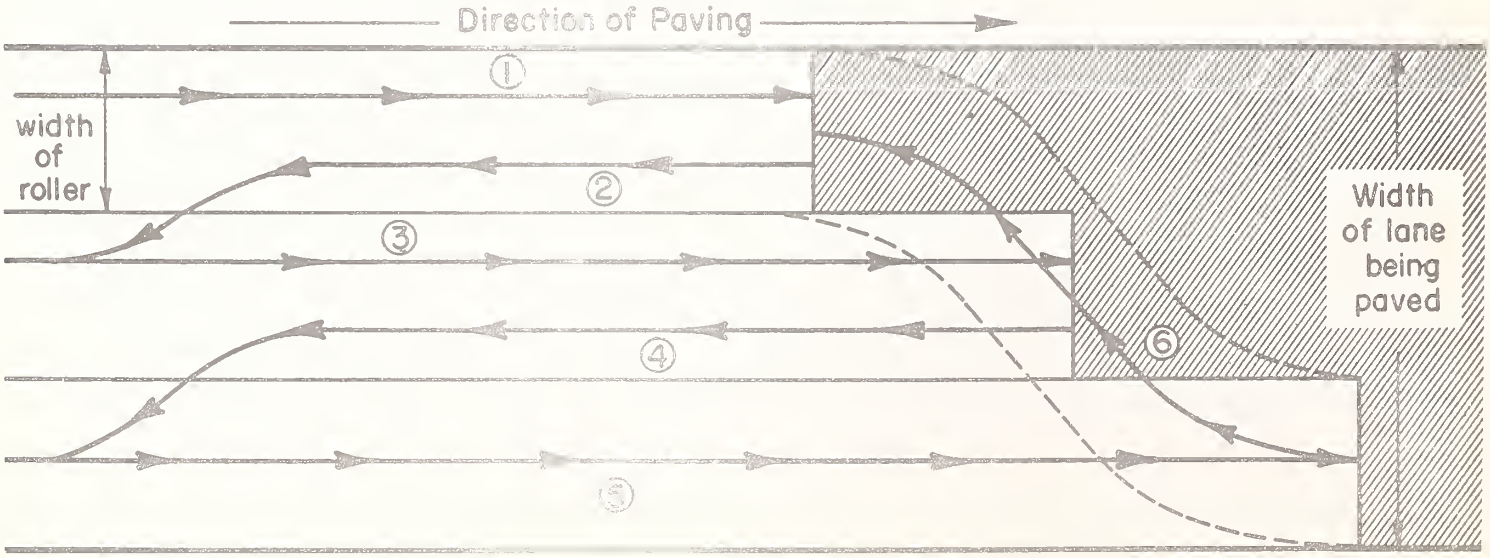
These pictures show the right and wrong way of filling chuckholes in an area to be paved.

Fig. IV-10B



Right and wrong way of placing leveling courses.

Fig. IV-10C



A proper pattern of rolling a pavement is shown in the drawing. In this case the roller operates on three lanes, as the pavement is three times wider than the roller. In the top lane the roller advances (1) with the drive wheel forward and returns (2) in the same lane. The roller moves to the next lane as shown at the left. Moving from left to right (3) the roller moves beyond the end of the first compacted lane so that the ridges created by changing direction do not match. The roller returns to the left (4) following exactly the same path as in the previous pass (3). After moving into the lower lane as shown at the left, the roller proceeds from left to right and continues until beyond the ends of the first two compacted lanes. The dotted lines show a path to follow in returning to the upper lane which would smooth out the side and end ridges. An alternate procedure is to give the bottom lane another rolling by returning along (5) from right to left and returning to the top lane at the left.

mediate and finish rolling. Before the Resident Engineer permits a vibratory, he should request approval through channels, from the Construction Division in Helena.

Compaction Method No. 2

Compaction method No. 2 is an end result method of construction. The compaction method is up to the contractor for his choice of rollers and sequence of rolling. However, the State has control of the density and has set his requirement of 97 percent of density of a test specimen made from the mix used at the job site.

Compaction method No. 2 is mandatory for any hot plant mix asphalting performed between the dates of October 1 and May 1. It can also be directed during cool weather if deemed to be in the best interest of the State.

A nuclear gauge is used to determine the correct rolling sequences and time needed for compaction, in order that 97 percent density can be obtained.

Breakdown rolling should follow the paver as closely as possible without cracking or distorting the mat or having the mix pick up on the roller wheels. Intermediate and final rolling should follow initial rolling as soon as practical so that all rolling can be completed before the mat becomes too cold. Correct mixing demands a temperature from about 240 degrees to approximately 305 degrees depending on the temperature viscosity range recommended by the manufacturer. Similarly, correct rolling demands that the temperature be within a range that is compatible with mix characteristics and weather conditions.

G. Joints and Surface Smoothness

Poorly constructed transverse and longitudinal joints can generate a great deal of public criticism. Some criticism is warranted if joints are not smooth, are obviously visible and have the appearance of being very short lived. Take care with joints. Make them as good as is possible and be especially particular in constructing an asphalt surface next to a Portland cement concrete slab. The concrete edge should be painted and the mix crowded tightly against the concrete face. Asphalt mix when compacted should be just a fraction of an inch high.

1. Longitudinal joints. The width of spreading the mix should be planned so longitudinal joints in the first layer are off set at least six inches from those in the layer above. Longitudinal joints that are not off set are undesirable because it will allow water and debris to enter the crack.

Longitudinal joints are formed with a single paver or with two pavers, one of which is ahead of the other. The latter method of forming joints is called paving in "echelon" and does have an advantage of providing a hot joint between the two lanes.

The majority of longitudinal joints are formed cold. Even with very careful treatment they are not the best. Two joint forming methods are used: (1) The paver should be adjusted so that material overlaps slightly into the finished lane and is placed slightly into the finished lane and is placed slightly high so the correct thickness will result when compacted. With this method the first lane is rolled over the edge. (2) A strip about 2 inches wide is left by rolling and compacting with rolling of the adjacent lane. This method works extremely well in hot weather or when the material at the joint faces is hot.

Forming the longitudinal joint by echelon paving requires each paver to place exactly the same depth of material but gives an excellent joint. Full width paving is ideal but can be used only where traffic is not carried through the job.

2. Transverse Joints. Many methods are used by various contractors to construct transverse joints but not all methods give a smooth ride over the joint. Transverse joints are to be made by cutting back to the previously placed course, thereby exposing that course to its full depth or by the use of a bulkhead.

The use of a board (bulkhead) of the proper thickness is permissable, but it should be checked with a straight edge before the joint is completed. Bulkheads used in low stability mixes are apt to shove ahead when rolled. If shoving does occur the mat thickness will be too thin and the material will have to be trimmed as though no bulkhead was used.

When spreading operations are resumed, the joint face should be sprayed or painted with a thin coat of asphalt before the fresh material is placed against it. The paver screed should be heated and the depth set so that finished compaction will provide a smooth junction of the new and the old material. Freshly made joints should be thoroughly compacted by normal rolling and cross rollings.

Care should be taken when doing any handwork in constructing transverse joints to assure that coarse material is raked and wasted.

Surface smoothness. Montana specifications allow a variance of no more than 3/16" measured from a ten foot straight edge held parallel to the center line of the roadway. The straight edge may be wood or metal, or it may be a rolling straight edge that indicates irregularity as the inspector pushes it along.

LANES THROUGH INTERSECTIONS

Fig. 4-25

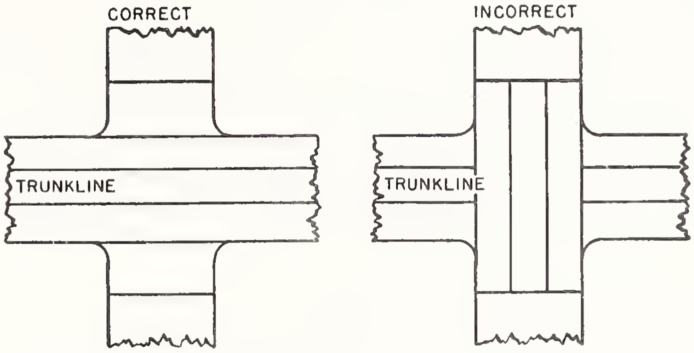


Fig. IV-11A

LANE TRANSITION FOR VARYING WIDTHS

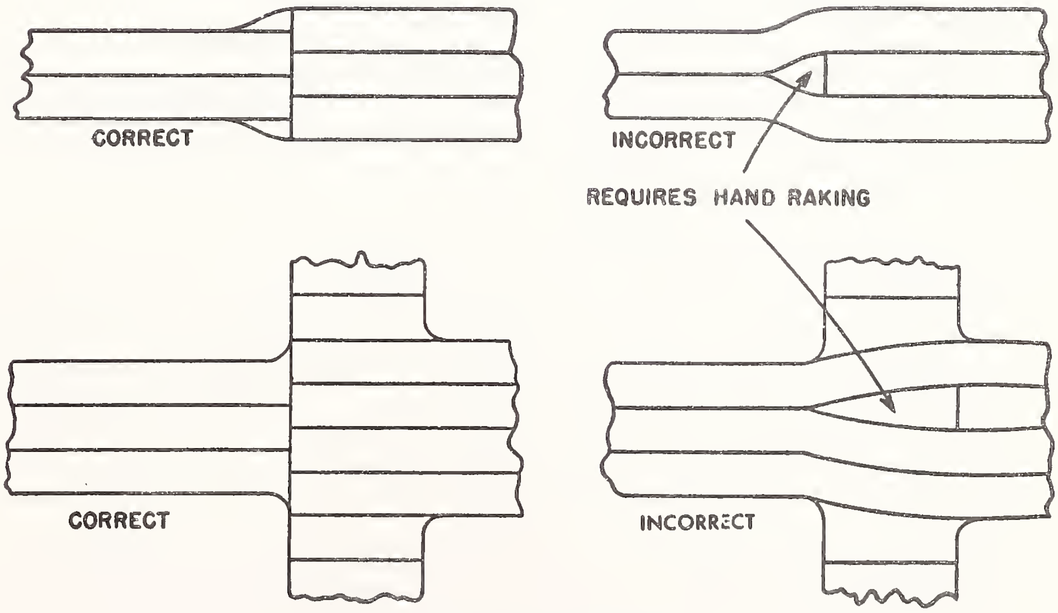


Fig. IV-11B

The finished surface of each course should be thoroughly covered by the straight edge operation and irregularities that are detected should be corrected immediately by removing or adding material. Corrections made while the mat is warm will not be as noticiable as those made later. The final course of plant mix can usually be placed much more uniformly if the required smoothness is obtained in the first course. Corrections are more easily made in the first course than they are in the final course. After final rolling of the finished course is completed, the surface should again be checked, areas that exceed the surface tolerance should be marked and corrections made before the work is accepted. Sometimes corrections can be made by cross rolling, but if corrections cannot be accomplished, the areas are to be removed and replaced to meet the proper surface smoothness.

H. Paving Inspectors Checklist

Many of the important functions of paving inspection are summarized in the following checklist.

1. Each piece of equipment intended for use on the work should be examined to be sure that it is in good repair and proper adjustment. Use a straightedge or stringline to check cutting edges, screeds, etc. Paving machine with loose controls will cause jerky or erratic operation of the screeds, tampers, tracks, etc. In general paving machines, should have about 1/16 to 1/8" more crown in the leading edge of the screed than in the trailing edge. This will increase the ironing action and decrease the tendency for the screed to drag the material.

2. Be sure that provisions for traffic control are well organized and that traffic control is functioning properly with the correct signs and sign sizes in their proper position. Use a pilot car or pickup when necessary to keep traffic off the fresh mat, for safety or to provide controlled movement.

3. Review the roadbed preparation, the need for tack coat, the need for brooming and cleaning. Tack coats are required between lifts or when traffic is present on preceeding surface. Be sure that ruts, potholes or surface smoothness that needs correction has been properly corrected. Tack coat should be applied to vertical edges of transverse and longitudinal joints and surfaces that will abutt the new pavement such as gutters, curbs, manholes, etc.

4. Hold conferenceswith the contractor to determine such paving necessities as: Paving schedules; Procedures for rejection of mix; Who is to issue and who is to receive instructions; Paving widths; General continuity of the operations, including the number of pavers and number of rollers to be used.

5. Be sure that the paver guidelines have been set properly.

6. Check the longitudinal and transverse joints for smoothness and appearance and require correction where deficiencies exist in smoothness.

7. Is truck driver technique correct to assure that trucks dumping into the paver hopper do not cause an adverse effect on the paving operation.

8. Make frequent temperature checks of the mix.

9. Constantly inspect the mat behind the paver for signs of roughness or non-uniformity of the mixture.

10. Observe the rolling operation to be sure that: The sequence is correct for existing conditions; the proper rolling methods are being used and that the rollers are being operated within a reasonable speed range. Make certain that the mat thickness is correct, or if not, that proper adjustments are being made.

11. Make frequent checks of the spread and keep records of truck loads used each day. Then check with the plant inspector concerning the daily totals and reconcile the quantities as soon as practical.

12. Make sure the job is in good shape before you leave at the end of the day, see that lights, barricades, signs, etc., are correctly placed and make certain that all signs not required, are removed or covered.

IV - 49 Road Mixed Asphalt Surfacing

49.00 References

Standard Specifications

49.01 General

Section 33 of the Standard Specifications was written in the "good old days" when the road-mix method was the only method available for constructing an asphalt-mix surfacing course. Modern plant-mix methods have almost entirely replaced road-mix, but there are instances where road-mix serves efficiently and economically. Temporary surfacing like detours, various improvement sections under State maintenance, access roads and transitions are examples where road-mix works nicely.

A few basic rules, if followed, will provide a very acceptable pavement of low type. These are proper weather conditions, uniform oil content, thorough mixing and more importantly a "laydown" patrol operator of considerable skill and experience.

49.02 Roadbed Preparation

The roadbed must be shaped to the required crown or "super" and cross-humps or dips at the quarter line and between, blue-tops will appear if the patrol operator tried to "skim" the top of each blue-top and then adjusts his blade up or down between blue-tops. These humps or dips can be picked out be stringline, Swedes levels, night inspection under headlights or by rod and level.

After the surface has been put in proper shape with watering, blading and rolling it must be kept in shape by continued watering, blading and some rolling until primed.

Some inspectors are fooled into thinking future courses of gravel or asphalt surfacing will take out the irregularities. These other layers can only modify the problem and at that only to a very minor degree. The result of attempting to cure an out-of-shape roadbed with another layer of asphalt is a reflection of the irregularity through to the riding surface. Correct these problems as they arise.

49.03 Equipment Inspection

The equipment must meet the applicable specifications.

Some of the more important considerations concern the tightness of ball joints on the patrol, its power capacity, straightness of the cutting blade, and operating conditions of the hydraulic controls. These should cause rapid smooth movements in the blade and control arm rods. An old out of adjustment patrol just won't lay a smooth surface. Smooth tires will help give a better appearance to the matt.

The asphalt distributor should have a trial run made so the application rate, spray pattern, force of spray etc. can be observed, then irregularities can be corrected before work is begun.

49.04 Mixing

Mixing serves to coat the aggregate and to all the "cut-back" to evaporate from the asphalt.

The aggregate will be formed into a windrow or a number of windrows depending on how much aggregate is in each lift. Each windrow must be of the same width and height throughout its length to assure an even distribution of asphalt.

After each application of bitumen, the material will be "processed" by blade mixing back and forth across the roadway to assure an even coating on all the aggregate. Mixing can also be done by rotary mixers or traveling plants. The rotary traveling plant tills the gravel as it introduces asphalt while moving along the windrow. Numerous passes will be necessary to obtain a thorough mix by most traveling plants.

An inspector must use considerable judgment and rely on experience to know whether mixing is adequate.

When the correct percent of asphalt has been mixed into the gravel, it is windrowed into an oil stack. Asphalt is sprayed into the "laid out" gravel stock then mixed and this process continued until the desired asphalt percentage has been thoroughly mixed. The mix should "crawl" if the oil content is proper, and should appear fairly dark. A brown colored stock is too lean and a very black appearance indicates too much oil. The appearance of uncoated particles "white spots" means mixing wasn't adequate, or the asphalt percentage too low. The number of gallons per cubic yard is determined according to the volume of the gravel stock on a "per foot" basis and the percent of asphalt desired.

Watch for "oil balls". Too much water in a fine gravel, too much oil placed all at one time and too little processing are causes of "oil balls". Continue mixing until all "oil balls" are broken up.

Mix temperature is important so check the specifications for the proper mixing range for the type of asphalt being used.

49.05 Spreading and Compacting

After thorough mixing, the material will be spread by a patrol in successive passes until all of the oil stock is laid. A roller will follow the patrol after the initial blade layout is done compacting each pass of the patrol. The patrol operator can judge by the feel of his machine whether the roller is compacting too soon or not soon enough so he should have a fairly free hand at directing the roller. Check the surface with a 10 foot straight edge and correct any ruts or depressions greater than three-eights (3/8) inch.

49.06 Records

The inspector should record weather conditions, aggregate and bitumen quantities used each day, asphalt samples taken, stationing where worked, rejected work (if any) inspectors on the job, record of equipment inspected or othertimes of importance in determining and documenting pay quantities.

COUNTY ROAD SEPARATION @ STA. 472+15.0
PROJECT NO. I 90-17(93)14 UNIT 2
RECORD OF REINFORCING STEEL INSPECTION

The placement of the reinforcing steel was inspected before the placement of concrete on the dates and in accordance with the detail drawings indicated.

— SUBSTRUCTURE —

	FOOTINGS	LOWER STUB COLUMNS	UPPER COLUMNS AND STRUT	CROSS BEAM	REMARKS
BENT NO.	1	1	1	1	NONE
DWG. NO.	3217	3217	3217	3217	
DATE	6-3-68	6-4-68	6-7-68	6-14-68	
SIGNATURE	William R Smith	William R Smith	Ray W. Waxely	Ray W. Waxely	
BENT NO.	2	2 - Columns		2	NONE
DWG. NO.	3218	3218		3218	
DATE	6-7-68	6-17-68		6-21-68	
SIGNATURE	Ray W. Waxely	Ray W. Waxely		William R. Smith	
BENT NO.	3	3- Columns		3	Footings lowered as shown on "As Built" drawings & C-1 bars placed as shown
DWG. NO.	3219	3219		3219	
DATE	6-24-68	6-26-68		7-2-68	
SIGNATURE	William R. Smith	William R. Smith		Ray W. Waxley	
BENT NO.				4	NONE
DWG. NO.				3220	
DATE				6-28-68	
SIGNATURE				William R. Smith	

— SUPERSTRUCTURE —

	BACKWALL	BACKWALL	DIAPHRAGMS	DECK SLAB	
BENT NO.	1	4			
DWG NO.	3217	3220			
DATE	7-29-68	7-29-68			
SIGNATURE	William R. Smith	William R. Smith			
SPAN NO			1, 2 & 3	1	2 Additional S100 bars required see "As Built" plans
DWG. NO.			3221 & SL-1	3221 & SL-1	
DATE			7-31-68	8-5-68	
SIGNATURE			Ray W Waxley	William R Smith	

Figure IV - 12

17 COUNTY ROAD SEPARATION @ STA. 472+15.0
PROJECT NO. I-90-17(93)14 UNIT 2
RECORD OF REINFORCING STEEL INSPECTION

— SUPERSTRUCTURE (CONT'D.) —

	DECK SLAB	CURBS RT.	CURBS LT.
SPAN NO.	2 & 3	1, 2 & 3	1, 2 & 3
DWG. NO.	3221 & SL-1	3221 & SL-1	3221 & SL-1
DATE	8-8-68	8-12-68	8-16-68
SIGNATURE	William R. Smith	William R. Smith	Ray W. Waxley
BENT NO.			
DWG. NO.			
DATE			
SIGNATURE			
BENT NO.			
DWG. NO.			
DATE			
SIGNATURE			

COUNTY ROAD SEPARATION @ STA. 472+15.0
PROJECT NO. I-90-17(93) 14 UNIT 2
RECORD OF REINFORCING STEEL INSPECTION

— SUPERSTRUCTURE (CONT'D.) —

END POSTS	REMARKS
	NONE
1 SL-1 8-20-68 Ray W. Waxley	NONE
4 SL-1 8-23-68 Ray W. Waxley	NONE

Figure IV - 12A

IV-50 Seal Coat

50.00 References

Standard Specifications Section 34

Construction Manual Section 48.00

50.01 General

A seal coat is a single application of bituminous material covered with stone chips, on a prepared asphalt surface. Although not limited to the following, Seal Coats; (1) Help prevent the entrance of moisture, (2) Reduce the circulation of air through the mat thereby lessening the effect of oxidation, (3) Provide a more skid resistant surface texture, (4) Rejuvenate a weathered surface, and (5) Delay further raveling, (6) Provide more light reflection from headlights for better visibility at night.

50.02 Material

A. Bituminous Material

The bituminous material used should develop high cementing properties immediately upon application of the cover aggregate. It is important that the consistency of the bituminous material be such that it will not penetrate appreciably into the underlying surface and will hold the cover aggregate. Although many different types of asphalt can be used for seal coats, CRS-2 is usually specified.

B. Cover Material

The cover aggregate should be as close to uniform size as practical so that only one layer of aggregate will result.

The maximum size of aggregate will determine the smoothness and quietness of the riding surface. Aggregates smaller than one-half (½) inch are generally specified. The preferred shapes of the aggregate are cubical or pyramidal. Although flat and elongated particles are less desirable, they are almost unavoidable as a result of the crusher type and geologic characteristics of the aggregate.

Asphalt may not stick to dusty or dirty aggregate so be sure the aggregate is clean.

See the plans for the type and grading of aggregates specified.

50.03 Roadway Surface Preparation

Just before the application of bituminous material, the roadway surface must be swept clean of all dirt and dust.

If the surface texture of the roadway is such that rapid absorption takes place, the engineer can direct a preliminary application of asphalt. The rate of this application should be very lean, approximately 0.1 gallons per square yard but may have to be adjusted after the results of the first shot are known.

50.04 Equipment

A. Bituminous Equipment

Refer to 48.03 Construction Manual

B. Aggregate Equipment

1. Spreader

A self-propelled spreader is commonly used for application of the cover aggregate. The machine is capable of making a very uniform and continuous application of cover aggregate and is able to keep up with the asphalt distribution.

Before beginning, the inspector should make certain the spreader is in good operating condition, and all adjustments have been made according to the manufacturers instructions. All truck hitches are to be checked so that thev connect quickly and positively to the spreader.

2. Rollers

Rolling must be done by pneumatic tired rollers capable of a ground contact pressure of not less than 50 psi nor more than 75 psi. Two rollers must be used for each spreader.

50.05 Application

A. Bituminous Material

Weather is an extremely important factor in obtaining a successful seal coat. The surface of the roadway must not be wet or damp when the asphalt is applied. The temperature must be warm enough so that the asphalt does not cool to the point where the cover aggregate will not adhere.

A seal coat is not to be applied to a newly constructed or reconditioned surface until 10 days after the surface has been constructed. Twenty-one days must elapse before a seal coat is applied to a new plant mix bituminous surface.

The bituminous material is applied with a distributor immediately after the roadway surface has been swept clean. The rate of application is usually about 0.30 gallon per square yard, however, the rate should be varied dependent on the characteristics of the surface being sealed.

B. Cover Material

All aggregate needed for the planned spread should be on hand before starting. When the distributor moves forward to spray the asphalt, the aggregate spreader should start right behind it. It is essential that the asphalt be covered within one minute or the increase in viscosity that takes place within that time may prevent good wetting and binding of the aggregate.

The aggregate must be spread uniformly and at a rate of approximately 10 pounds per square yard. The rate will require adjustment. In a single application, aggregate normally will not stick more than one particle thick to the asphalt, so it is wasteful to apply a rate greater than a single layer in thickness. An inspector can tell fairly close whether the rate is proper by looking straight down at the spaces between the aggregate. The asphalt should be visible and be about as large as a pin head.

A high degree of control is possible with self-propelled aggregate spreaders. A uniform application rate can be assured with a properly adjusted spreader if a tachometer is used to maintain uniform speed. Another help in controlling distribution rates is laying off the length which each truck load of aggregate should cover.

The aggregate trucks should be routed to the spreader in a direction opposite to the progress of the surface treatment operation. This prevents them from turning on the freshly placed treatment. All trucks should be required to turn around at a designated spot away from the new work for their return trip to the stockpile.

Piles of excess aggregate that may occur from spills should be removed immediately with square end shovels. In areas where application is insufficient, additional aggregate should be added. A truck with a workman is to be made ready when called for this purpose. With a good operator and properly adjusted aggregate spreaders, hand work should be very limited.

Full width application of asphalt and aggregate will eliminate longitudinal joints, but in most surface treatment work traffic must be maintained and the joint is necessary. However, desirable, full width coverage of asphalt is limited by the width of spreader and capability of the distributor to apply full pressure to all parts of the spray bar.

In order to prevent aggregate from building up on the longitudinal joint, the edge of the aggregate spread should be about 3 to 6 inches from the edge of the full thickness of applied asphalt. This will allow a width which can be overlapped when the asphalt is applied in adjacent lane. Then, when the aggregate is spread for the full width in the next lane there will be no build-up at the joint. The width of the asphalt strip left exposed will vary, depending on whether the height of the spray bar is set for a double or a triple lap and on the spacing of the nozzles.

If possible, the longitudinal joint should be along the center line of the pavement being treated. An established guideline should be used to assure a straight longitudinal joint.

Rough and unsightly transverse joints can be avoided by starting and stopping the asphalt and aggregate spread on building paper. The paper should be placed across the lane to be treated and it should be placed so that the forward edge is at the desired joint location. The distributor, traveling at the correct speed for the desired application rate, should start spraying on the paper so that when it reaches the exposed surface the spray bar is making a full, uniform application. A second length of building paper should be placed across the lane at the predetermined cut-off point for the distributor. This will give a straight, sharp transverse joint. After the aggregate spreader has passed over it, the paper should be removed immediately and properly disposed of.

For the next application, the leading edge of the paper should be placed on the previously laid treatment so it will be about one-fourth (¼) inch ahead of the cut-off line. This will prevent a gap between the two spreads.

Rolling seats the aggregate in the asphalt and thus promotes the bond which is necessary to resist traffic stress.

Rolling should begin with a pneumatic tired roller immediately after distribution of the cover material and continue until the aggregate is properly seated in the binder. As soon as the asphalt has a definite set or hardening, rolling should be discontinued or the bond between the surface and aggregate might be broken by the roller. Rolling should begin at the outer edge of the treatment and proceed in a longitudinal direction, working toward the center of the road. Each trip should overlap the previous trip by about one-half the width of the front wheels or roll.

In spite of all precautions, there usually will be some loose aggregate on the road surface after the rolling operation is completed. Before the adjacent lane is covered with asphalt, loose aggregate should be swept from along the joint and, if necessary, from the rest of the uncovered lane.

Aggregate which does not stick creates a problem since tires on fast-moving vehicles will pick up the loose particles and throw them against following vehicles, often damaging headlights, windshields, and finish. This loose aggregate may be removed by lightly brooming with a rotary power broom during the cool of early morning, after final set of the asphalt has occurred.

50.06 Traffic Control

Seal coating is a fast moving operation and traffic control must be geared accordingly. Signs must be portable and should be moved frequently so they are close to the operation.

While the seal coating operation is underway flagmen and pilot cars will be necessary to move traffic through the work area. Traffic should not be allowed to come near the distributor while it is in operation.

Immediately after completion of the aggregate cover the road shall be opened to traffic for a period not less than 48 hours with traffic control in effect. During this period pilot cars must be utilized on a 24 hour basis, to hold traffic speed down to about 15 MPH. During this period the contractor must maintain the surface by brooming and rolling. Any breaks, irregularities or deficiences must be repaired during this time.

50.07 Records

The inspector should record weather conditions, aggregate and bitumen used each day, asphalt samples taken, stationing where washed, rejected work (if any), inspectors on the job and record of equipment inspected.

If any delays are encountered, such as equipment breakdowns or insufficient number of workmen, it should be noted to help evaluate possible liquidated damages.

IV-51 Portland Cement - Concrete Pavement

51.00 References

Standard Specifications, Sections 39, 40.
Standard Drawings Nos. 39-01, 39-02, 39-03, 39-04, 39-09, 39-10, 39-12 and 39-13.

Construction Manual Sections IV-45, IV-46.

51.01 General

The construction of concrete pavement is a highly mechanized operation requiring a thorough knowledge of equipment, methods, materials and their proportioning. Paving inspectors should be very familiar with the Plans, Specifications, Special Provisions, Construction Details and orders of the work.

Before the start of paving operations a meeting should be held with the contractor's supervisory personnel and the Resident Engineer with his inspection staff to discuss: Material sources, handling of materials, plant site, equipment, methods of operation, scheduling and the specification requirements. A resume of this meeting should be written by the Resident Engineer and copies sent to the contractor and Division Engineer.

Some essentials to observe in producing a high quality concrete pavement are:

1. Accurate proportioning of aggregate and cement.
2. Absolute control of the water content of the mix.
3. Preventing segregation in the concrete.
4. Adequate number and proper spacing of finishing equipment to handle production.
5. Properly trained equipment operators and finishers.
6. Proper curing.
7. Proper sawing and jointing.

51.02 Preparations Before Placing Concrete

Montana's concrete pavement is almost always placed upon a cement treated base. The engineer should carefully inspect the cement treated base for visible indication of surface defects, ability to support the paving machines and design strength properties before allowing placement of the concrete pavement. Placement of concrete is limited by specification to seven (7) days after the curing seal has been applied to the cement treated base. The following discussion will aid the engineer who encounters formed concrete paving.

A. Forms-Form Setting & Alignment

Forms should be checked to insure that they meet the requirements for dimensions, material and supporting capabilities; are clean, oiled and straight; the face perpendicular to the base; flanges are not bent; and locking devices are in proper working order. The straightness of all forms should be tested with a ten (10) foot straight edge before they are used. Those forms which show a variation in the top surface of more than 1/8 inch or in the vertical face of more than 1/4 inch should be rejected. Forms with loose or missing stake pockets or wedges or with missing or inoperative end lock plates should not be permitted on the job. The pins used to held the forms in position should be at least 18 inches long for forms 8 inch or less in height and 24 inch long for 10 inch forms.

Pins set accurately to line should be driven at fifty (50) foot intervals on tangents and straight grades and at closer intervals on sharp horizontal or vertical curves. Pins should be set a sufficient distance outside the form line to clear the grader blade and wheels, when a form grader is used. After the subgrade is cut it may be necessary to fill some areas (this should not be permitted as a general practice), these areas should be filled and compacted before the forms are set.

The forms should rest on a firm foundation throughout their entire length. Any loose material provided inside and outside the forms for tampers, must be firmly tamped under the forms. Form setters should not be allowed to lift a form to bring it to proper grade before locking the pins, as settlement will occur at these locations. Locking devices must be properly fastened. The correct width between forms and the correct distance from centerline must be assured. A smooth grade line at the correct elevation must be maintained. After the forms are set and properly tamped, their horizontal and vertical alignment may be checked by sighting along the tops of the forms. If irregularities exceeding 1/8 inch from true grade or 1/4 inch from true alignment are detected and adjustment made, the forms should be retamped.

At least fifteen hundred (1500) feet of properly set and trued forms should precede the concreting operation. Unless this much distance is maintained, placing operations tend to crowd the form setting crews with consequent tendency to slight these important operations.

Forms should be oiled before use with an approved form oil to prevent concrete from sticking to the forms. They should be cleaned and and re-inspected after use and any bent, broken or otherwise damaged forms removed from the work. The subgrade is trimmed to crown and grade after the forms are set, properly aligned and accepted. Low spots are to be filled and recompacted. The sub-grade should be checked with a steel template immediately ahead of the paving operation. In addition to templating, frequent checking should be done of uncrowned sections by measuring down to the subgrade from a taut stringline or wire stretched across the forms. These measurements should be recorded by the inspector.

The subgrade should be moistened before any fresh concrete is placed upon it, to reduce cracking in the concrete caused by an excessive moisture loss or volume changes in the subgrade soil. Sprinkling just ahead of the paving operation is but a more adequate procedure is to thoroughly wet the subgrade some hours before concreting. This will allow thorough penetration but prevent muddy spots and surface water.

B. Equipment - Inspection

Before any concreting work is done all equipment should be checked; for compliance with the specifications for mechanical conditions; for capacity; to make certain that all necessary equipment is on the job and available for use and to assure that plant production, paver capacity and the number of hauling units are matched to allow uniform placement speed.

1. Batching Plant Equipment

(a) Hoppers and bins should be set level and loaded for at least 24 hours before calibrating. Bins for aggregate or bulk cement should be tight and constructed to allow free flow of material with no accumulation in the corners. Rectangular shaped bins reduce accumulation or bulk of material. Bins should be carefully loaded to avoid segregation, contamination or intermingling of the different materials.

The weighing hopper should empty completely and be large enough to contain the batch being weighed without overflow or "coning" against the bottom hopper. The cement must not be weighted with the aggregates but in a separate hopper.

(b) The working parts of the weighing unit (knife edges, shackles, weighing arms) must be free of avoidable friction, in good condition, protected from falling or adhering material and be readily accessible for inspection. There should be no attachments to the scales or weigh hopper which might restrict the free movement of any part of the weighing mechanism or cause any inassurate weighing during actual operation.

Cement hoppers should be vented to permit escape of air and equipped with a canvas trunk to prevent loss of cement during discharge.

Whether scales are simple or complex they should be checked at regular intervals to insure that the designated quantity of material is actually being delivered.

Zero balancing should be checked twice a day with the weigh hopper empty. The contractor is to furnish all weights, equipment and labor necessary to calibrate the scales. Calibration and sensitivity should be checked at regular intervals to insure that the quantity of material in the hopper is correctly shown on the weigh beam or dial. Checking may be accomplished by balancing the scales under no load then suspending standard fifty (50) pound weights from the weigh hopper. Ten, 50 pound weights are added, one by one, observing and recording the scale reading, then these weights are replaced by enough material to give the same scale reading. Leave the material on the scales and add the weights again, observing and recording the reading obtained. Again, replace the weights with enough material to provide the same scale reading. This operation is repeated until the total weight exceeds that which will be used in batching. Cement scales must be accurate to within 0.5 percent of the net load being weighed. Aggregate scales are to be accurate within one percent of the net load being weighed. Water measuring or weighing equipment is to be accurate to within two percent.

A five pound weight for aggregates or a two pound weight for cement should be used to check the scale sensitively during the calibration test. When volumetric batching is an acceptable practice the inspector must measure the various batching containers to determine their volume. Saturated surface-dry batch weights of the aggregates must be converted to an equivalent volume measure. Allowance must be made for the volume changes caused by bulking of the fine aggregates and changing moisture content in aggregates.

(c) Water gauges, metering equipment, valves and tanks must be inspected to insure readability, accuracy and water tightness. The quantity of water discharged into the drum may be checked against the gauge reading by disconnecting the water line, diverting the flow into a container and weighing the quantity discharged at various settings. The trip valve should be timed to introduce some water into the batch plant drum ahead of solid materials and continue to flow after all other ingredients are in and the mixing cycle has started.

(d) Air entraining agent dispensers should be inspected frequently to insure that the intake and discharge lines are clear, parts open and close properly and air vents are clear. A transparent plastic line from the dispensing unit to the drum will permit observation of the material flow. The dispenser should be calibrated through its full working range and should dispense the agent within about three percent of the desired quantity. Calibration is accomplished by measuring the quantity dispensed for various settings.

(e) Regardless of the mixing equipment used, there are certain checks which should be made to insure a quality product.

(1) Badly worn mixing blades cause insufficient mixing. Blade wear, checked by a stringline or straight edge placed along the length of the blade, which exceeds 3/4" or more should be replaced. Blades and mixing drum should be free of hardened concrete and drums should be in a good condition to avoid spillage either on the ground or between compartments in multiple batch mixers.

(2) The loading skip, of on -site mixers must be large enough to hold a full batch with no spillage, be clean, smooth and below all materials to be discharged into the mixing drum. Lifting cables must assure proper operation and have a sufficient safety factor. A boom of sufficient length, elevated to just clear the forms with gates open, will properly locate discharge and minimize free-fall of the mix to the subgrade. Bucket gates should close tightly to prevent leakage of mortar. The automatic timing device should be checked and adjusted with a stop watch at least once a day while the mixer is loaded. Mixing time is not to be less than sixty seconds. Drum rotation speed must be checked for compliance with the speed listed on the manufacturer's name plate. Batch meters must be provided and be checked to assure complete mixing has occurred.

(f) Batch trucks, with compartmented boxes, used to haul dry batches should have sufficient capacity to hold batches without mounding; have adequate protection against wind and rain; gates should be tight and the batches should discharge all materials completely.

(g) The following are some items to check when truck or transit mixed concrete is allowed by written permission.

(1) Mixers must be approved, have a legible name plate showing capacity and drum speed and in a condition good enough to insure protection of uniform and well mixed concrete.

(2) Water measuring devices and air entraining dispenser should be calibrated and checked.

(3) Wash water is to be carried in an auxiliary tank and if this water is to be used in the succeeding batch a device must be provided to accurately measure this water.

(4) Mixer drums are to be checked for excessively worn blades and hardened concrete.

(5) Drum or blade speed should be within the specification and recommended limits.

(6) Trucks are to be equipped with a revolution counter. Mixing speed of the drum must be within the range of 4 to 15 revolutions per minute. Agitation speed is considerably slow and set by specification to the range of 2 to 6 revolutions per minute.

(h) Concrete mixed in a central plant and transported to the work site may be hauled in agitator truck of approved design. Agitation speed is controlled to no less than two nor greater than six r.p.m.

2. Finishing Equipment

A. The many types of finishing equipment whether manual or machine operated are to be carefully checked to insure continued accurate strike-off and surface smoothness.

(1) The elevation of the bottom of the distributing device and strike-off on the mechanical spreader, are adjustable the strike-off should be set level with the top of the forms and the visible gauges should read zero. The strike-off should be adjusted for proper thickness and the distributing device adjusted so that some concrete will be carried in front of the strike-off. The inspector should observe as these adjustments are being made to insure accurate adjustments have occurred.

(2) The transverse finishing machine has 2 transverse screeds which must be checked for signs of excessive wear on their wearing plates (these ride on the forms) and may be done as follows. Center the screed and lift off of the forms; stretch fine wires taut between the forms at the front and back of each screed; place blocks of uniform thickness or top of the wires at each form then lower the screeds. The proper crown is then placed in the screed by measuring between the taut wire and the face of the screed and adjusting the hanger bolts. The front screed should be tilted with the front edge slightly higher. The rear screed should be set flat or with no more than 1/16 inch tilt. When two finishing machines are used, both screeds on the rear machine should have little or no tilt.

B. Adjustment of the longitudinal float finisher is extremely important since this machine corrects any irregularities left by preceding operations.

(1) Straight-edge the float along its centerline and both edges.

(2) All four ends of the transverse tracks which carry the float assembly should be the same distance above the plane of the bottom of the wheels. Taut wires are placed across the top of forms and the tracks are adjusted to conform to proper cross-section of the finished roadway. Two wires should then be stretched across the top of forms, one near the front and one near the rear of the float. All four corners of the float should be the same distance from the wire at a distance equal to the

ordinate of the desired cross-section, when the float is lowered. For the above check procedure the float should weigh about the same as it will under actual operation, including the operator. Scrapers should be in good condition and kept in tight contact with the flanged wheels or forms at all times.

C. The transverse float finisher may be substituted for the longitudinal float finisher. This machine is carried on a long wheel base that rides on the forms and finishes the concrete with transverse oscillating screeds and a stationary float. The front screed normally rides on the forms and may be checked as described under Transverse Finishing Machine. The second screed and the float do not ride on the forms but are suspended from the frame, therefore, their elevation is much less affected by form irregularities. Both screeds and the float should be adjusted to the proposed cross-section. Care should be taken that when they are in the down position, the ends of the screeds and the float are set to about the elevation of the forms. Small final adjustments are made after start of paving to get the exact cross-section and proper surface finish.

D. Vibrators should be checked before their use and frequently during use to assure that vibration frequency, impulses, and strokes meet the specifications. Hand vibrators should operate at a frequency of at least 4500 impulses per minute and vibrators that are a part of the finishing equipment should have a frequency of at least 3500 impulses per minute.

E. The subgrade check template is used to assure proper thickness and must not be used to do any cutting. The template should be placed on the forms, a light wire stretched across them, the distance from the wire to the lower edge of the template measured and any needed adjustment made.

F. All hand tools and auxiliary equipment should be checked before concreting operations begin. Their use, with the exception of the edger, should be kept to a minimum.

51.03 Concrete Production

The batch plant inspector is responsible for control of materials and batching operations. His duties will start at the time materials are being accumulated and continue until final records for the paving portion of the contract are complete. He must be familiar with the source and type of aggregate intended for use, mix proportions, moisture content, method of determining scale weights, batching equipment, tests and reports. The inspector should familiarize himself with the manufacturer's brochures on the batching equipment to understand its operation. The contractor will normally have this information. If not, it may be obtained from the manufacturer's representative. The field laboratory should be in a location which permits the maximum number of operations to be observed while performing the necessary functions in the laboratory and be frequently cleaned with equipment kept in an orderly manner. Before the paving operations begin, a concrete mix design will be furnished by the Helena laboratory to the Resident Engineer who should then review this as well as the total concreting operation with the plant inspector.

A. Material Inspections

The Resident Engineer and inspectors should be completely familiar with material specification requirements and insist that materials be tested and approved before being incorporated into the work.

1. The contractor's equipment used for material production must have been thoroughly inspected before it can be used in the concreting operation. Previous discussion in this manual, the specifications and equipment brochures should be consulted when inspecting the equipment and any faulty, inoperative, or damaged equipment be repaired or replaced. Faulty equipment is very frequently the cause of poor quality materials production.

2. Stockpile sites and storage bins should have positive means of preventing contamination and intermingling of the various aggregate sizes. The approximate base area of the finished pile should be estimated and the pile built up over this area in horizontal layers not to exceed three feet in depth. Do not cone aggregate stockpiles as this causes segregation. When the contractor elects to use a stacker, the pile should also be built up in horizontal layers. If the material is being dropped from a considerable height, the stacker should be equipped with a rock ladder or tremie to reduce the falling impact and prevent segregation. A brisk wind blowing through the falling aggregate will deposit the fines on the lee side of the pile while the larger particles remain on the opposite side. It is the contractor's responsibility to provide the specified gradation of the aggregate entering the mix. When crawler tractors are used on gravel stockpiles, the contractor must clean all caked dirt and mud from the track ways and from beneath the machine before running it on the pile. crawler-type can be used for stockpiling limestone or dolomite coarse aggregate, provided it is not operated over the materials to be used in the work.

   If the aggregates are hauled to the project in railroad cars, burlap and boards used to chink cracks in these cars become mixed with the material. A "grizzly" with a maximum of 6-inch square openings should be placed on top of the aggregate bins to catch foreign material previously missed. They should be cleaned at least twice daily to prevent forcing the foreign material through the "grizzly" openings and into the batch. Some contractors also place a "grizzly" on the skip of the paver.

   It is not permissible to use aggregates from ready-mix company's stockpiles, which are constantly being replenished. The inspector must guard against such use, insisting that stockpiles, separate from the ready-mix company's commercial piles, be furnished for State use.

3. Weigh bins do not always clean themselves after each batching cycle. The inspector should check the cement and aggregate bins for cleaning frequently at the beginning of the job. If the cement becomes packed in the corners of the weigh bin, the correct weight will be shown on the scale but something less than the full weight will actually reach the batch. It is sometimes possible to notice this deficiency by checking to see that the scale goes back to zero after emptying. This condition can be corrected by rounding out such dead areas in the bin design or by means of vibrators attached to the bin sides.

   When changing scale weights for batch correction in the aggregates, be sure that the set screws, holding the counterweights in position on the beam arms, are firmly tightened with pliers by the operator. Constant vibration around the plant tends to move these weights, causing an incorrect amount of aggregate to enter the batch.

   If rain comes at any time while the aggregate bins are loaded, the water will collect in the material at the bottom of the bins. Two or three truck loads of each size aggregate should be taken from the bins and hauled back into the stockpiles before batching begins. When this is not done, the moisture content of the first few batches will be excessive and sloppy concrete will result at the mixer. Many contractors allow the bins to emply at the end of the day for the above reason.

   Regardless of whether aggregates are tested at the point of production on the job site, test reports must be on file showing the aggregates are acceptable prior to their use in the work.

4. The cement receiving weighing and handling operation must be inspected to assure that the cement; is accurately weighed and properly included into the batch with no spillage.

   The cement used at the plant shall be checked against the cement required by the total number of batches or cubic yards mixed. These checks are to be made during the progress of the work.

   The initial check of cement used against the cement required should be made at or near the close of the first or second full day's paving operation. The initial and successive cement checks should be made between carloads and with cement silo and storage or service bins completely empty.

   Accurate, "empty bin" checks of the cement used in concrete proportioned at commercial ready-mixed plants, is usually impossible to make. Accordingly, it is extremely important that the Project Engineer and the paving plant inspector make certain that the inspection of the weighing and proportioning is full time and fully adequate; that the scales weighing the aggregates and cement are accurate; and that the weighing procedures are conducted in a careful and precise manner to insure the correct proportioning of aggregates and cement.

The field engineer and the plant inspector should make certain that air pressure in the cement delivery and storage system is not affecting the cement scale and cement weighing operation at either commercial ready-mixed concrete plants or proportioning plants. In some proportioning plants, if the service bin and the weighing hopper for cement are not adequately vented, air pressure buildup in the weighing hopper will cause underweighing of the cement. This can be positively checked by introducing cement into the weighing hopper until the scale indicates the correct quantity for a batch and then hold up the operation the scale fully loaded for a short period of time, sufficient to void any air pressure in the cement weighing hopper. If the cement scale is functioning properly, the scale beam and dial indicator will remain stable. If air pressure is affecting the weighing operation, the cement scale beam and dial indicator will show a decreased weight of cement as the air pressure reduced. All proportioning plants using air pressure to transfer or move cement within the plant should have this important item checked periodically. Cement must be handled and stored in a manner to prevent loss, wetting or contamination. Portland Cement is to be low alkali type II and furnished from pretested bins at the cement plant If there is no documentation accompanying the shipment of cement indicating that it has been tested, contact the Division Engineer immediately and arrange for proper testing. Cement sources should be known and approved, with the contractors knowledge, before operations begin to avoid the use of non-pretested cement. Different types of cement are allowed only by written permission. If more than one brand of cement is allowed no mixing of these brands will be permitted and they shall not be used alternately in any one pour.

5. Water that is suitable for drinking is acceptable for use in concrete unless it contains sugar. Water of a doubtful quality must be tested and be acceptable prior to incorporating in the mix. The intake end of the pipe or hose used in pumping mixing water from a stream or standing body of water is to be covered with wire mesh and so located that no foreign matter will enter. Hauling of mixing water should be done in clean, covered containers. Assurance of using acceptable water is the responsibility of the plant inspector for central or ready mixing and the responsibility of the slab inspector for on-the-job mixing.

6. Admixtures, except air entraining agent, may not be used without the written permission of the engineer. Samples of the proposed admixtures, unless records indicate those were previously approved, must be submitted to the laboratory before use.

Admixtures containing calcium chloride are not allowed. Type II-A cement will not meet the requirements for air entrainment. The air-entraining agent used to produce 5 to 9 percent air must have been approved by any Montana State Highway or Bureau of Public Roads or concrete laboratory regularly inspected by the Cement Reference Laboratory of the National Bureau of Standards. Evidence of this approval must be in the project files. An air entraining admixture made by neutralizing Vinsol resin with caustic soda may be used based on a contractor furnished certificate (pp. 187 Standard Specifications) and satisfactory test results from samples submitted to the Helena Laboratory.

B. Plant Inspection

When the plant inspector thinks of the entire paving project as a line operation, from raw material to finished slab, it is easier for him to align his inspection duties to function as a part of the production process and in this way he is better able to organize his work. The quality and volume of the concrete are equally dependent on each step along the production line and no amount of extra effort at one step can compensate for errors, omissions or inefficiencies at some previous step. The plant inspector should include the following as some of more important duties.

1. Observe the stockpiling and handling of materials to assure compliance with the specifications. Maintain inspection records to verify that all material is acceptable prior to incorporating into work. Make a periodic check daily of the amount of cement actually used by comparing the total quantity received with the theoretical quantity used, compensating for the cement remaining on hand.

2. Be familiar with the physical characteristics of aggregates, design mix proportions, the method of determining batch quantities, scale weights, yield, effective water, cement factor and the procedures for adjusting proportions because of changing moisture in the aggregates and yield when using air entrainment. The design mix as established and approved must be included in the permanent records of the project as well as records of any necessary adjustments in mix design.

3. Calibrate the weighing and measuring devices, balance scales and check calibration, and make a systematic and regular check of scale settings for batches to assure proper quantities are being dispensed. Scale settings are not to be made by the inspector since this is the responsibility of the contractor's men.

4. Make free moisture tests (AASHO T 142) quite frequently when the job starts, then after the work smooths out, fewer moisture tests are required except when there has been a change

in the moisture content. These tests are required to adjust batch weights and to insure that the maximum allowable water-cement ratio (0.53 or 6 gal. per sack net water content) is not being exceeded. Advise the inspector at the mixer immediately of any change in moisture content of the aggregates, and of the maximum gallons of water that may be added at the mixer without exceeding specification and design limits.

5. Check batch trucks used for transporting unmixed batches to the paver when this method is used to assure they conform with specification requirements and that the compartments are of sufficient size; are constructed in a manner to prevent loss of material and spillage or contamination from one compartment to the other; and that the total batch is discharged. Examine batches in which the cement is in contact with the aggregates in excess of 1½ hours and if lumps or a crust of hardened cement is found, discard the entire batch.

6. Require that central-mixed concrete be hauled in vehicles meeting specification requirements and in a manner to avoid segregation and be delivered at a site with proper consistency and workability before the concrete starts to take its initial set. Require agitating type trucks if these conditions cannot be met. The hauling unit for fresh or transit mixed concrete must have been approved in writing before use.

7. Assure that concrete is properly mixed, meets the slump and air content requirements is uniform and of the desired workability when delivered to the placing site. Wet or dry batches should be avoided and the slump of each batch held to within the approximate range of 3/4 inch to 1¼ inch.

C. Mixing Methods

Three general methods of ready mixing concrete; central plant mixing, combination mixing and transit mixing are allowed by Standard Specifications as well as the use of a proportioning plant with site mixing.

1. Central-mixed concrete has all ingredients mixed completely at a central-mixing plant either by the contractor or a commercial producer. It may be delivered in mixing, agitating or non-agitating trucks. If hauled in mixing or agitating equipment, it must be delivered and discharged into the work within 45 minutes after introduction of the ingredients. If hauled in non-agitating equipment, it shall be delivered and discharged within 30 minutes after the addition of the mixing water.

2. Combination-mixed concrete has all ingredients partially mixed at a central-mixing plant and the mixing completed in a truck mixer. It shall be delivered and discharged into the work within 1½ hours after introduction of the mixing water.

3. Transit-mixed concrete has aggregates and usually the cement proportioned at a central-mixing plant, all other ingredients proportioned by and all mixing done by transit mixer. Mixing shall begin within 30 minutes and the concrete shall be delivered and discharged into the work within 1½ hours after the cement is added to the batch. A satisfactory method of extending the haul time is to add the cement not at the batching plant, but at a point closer to the work. During the haul between the batch plant and the point at which the cement is added, the drum should not revolve as this subjects the aggregate to unnecessary grinding and degradation.

   At least 50 revolutions of the drum should occur at mixing speed after introduction of all ingredients but not more than 100 revolutions should be at a speed in excess of 6 revolutions per minute for transit-mixed concrete.

4. Site-mixed concrete has dry ingredients hauled to the mixer where water is added and the materials then mixed and placed.

   Regardless of the mixing method used, mixing time (checked twice daily) is to be no less than one minute after all ingredients have been added to the mixing drum. If water is added before other ingredients, the minimum mixing time will be one minute beginning immediately after all water and other ingredients have been added. The time required to load and discharge the skip of a site mixer is not part of the mixing time nor is the drum transfer time to be considered as mixing time. The total cycle for 34E drum pavers is a minimum of 73 seconds which allows 4 seconds for drum transfer time and 60 seconds for actual mixing. Do not use "slide rules" furnished by paver manufacturers to check mixing time as these usually count drum transfer time as mixing time.

D. Mixing Limitations

1. Cold Weather Concreting. Concreting operations are to be discontinued unless written authorization permits, when the air temperature is decreasing below 40° F in the shade away from artificial heat and shall not be resumed until air temperature in the shade reaches 35° F and is rising. When concrete is mixed and placed at air temperatures lower than those noted above, the temperature of the mixed concrete shall be not less than 50° F and more than 70° F at the time of placement. When it is necessary to heat mixing water and/or aggregates, they shall be heated to not less than 70° F nor more than 100° F in such a manner that the mass is uniformly heated. Overheated areas must be avoided. No concrete is to be placed on a frozen subgrade, nor are frozen aggregates or material containing frost lumps to be used in the concrete. Concrete placed during cold weather should be produced, delivered and finished in a manner to provide for a minimum

loss of heat. Finished concrete must be cured and protected to prevent freezing until the design strength is attained. In no event is any salt or similar chemical to be used to prevent the mix from freezing.

2. Hot Weather Concreting. When hot, dry and windy conditions prevail, it may become necessary to prevent rapid surface drying, rapid temperature changes and undesirable high temperatures in the concrete during the early stages of hardening. These conditions may remove moisture from the pavement surface faster than it can be replaced by normal bleeding causing plastic shrinkage cracks to form. It may be desirable to cool the mixing water and aggregate stockpiles to lower the temperature of the concrete. The forms may be cooled by sprinkling with water or by dragging a piece of wet burlap over them immediately ahead of concrete placement. The application or placement of curing materials immediately upon completion of finishing becomes extremely important and under some conditions it may be necessary to use wet burlap or cotton mats for the first 24 hours. The wet burlap or mats can then be used for the remaining curing period or removed and replaced with other curing materials.

3. Protection in Case of Rain. Prior to start of paving operations the inspector should be assured that the contractor has sufficient protective material on hand, such as burlap, polyethylene sheeting or other approved material, in case of rain. When sudden showers occur during paving or immediately after finishing, require the exposed surface of the fresh concrete to be covered to prevent washing the cement from the pavement surface. Mixing and placing of concrete should cease immediately in the event of rain. If rain continues only for a short time, the protective covering may be removed and finishing completed. When rain does continue, finishing may be accomplished after a fashion, by rolling back a few feet of the protective cover at a time and replacing it immediately after finishing is done. The pavement surface must be inspected as soon as possible to determine the extent of damage, and the contractor advised immediately of any corrective action or removal necessary.

4. Night Limitations. Night concreting operations may be conducted only upon written approval of an artificial lighting system that provides adequate light for proportioning, transportation, placing, finishing and inspection. Concreting should not be conducted when light conditions, whether natural or artificial greatly reduce workmanship or capacity to adequately inspect the proper mixing, placing, finishing or sawing operations.

51.04 Placing and Finishing Concrete

Concrete should be uniformly placed and distributed on a properly prepared and moistened subgrade. Care is to be exercised to prevent movement of forms, joint assemblies, dowels, expension joints etc. Any concrete spread by hand is to be done with a shovel rather than with rakes which tend to segregate the materials. Piles of dumped concrete tend to cause non-uniform consolidation and causes undue strain on the forms and spreaders which lead to undesired riding qualities. Concrete should be uniformly spread to avoid these difficulties.

A. Spreading and Shaping

The first operation in the actual construction the pavement slab is spreading the freshly placed concrete over the sub-base. Mechanical spreaders perform this function on large jobs by riding the forms and spreading the concrete with either a helical screw or a blade. The blade travels back and forth between the forms whereas the screw movement is rotational, either forward or reverse, and the elevation of blade or screw may be adjusted and set to properly distribute concrete.

The spreader strike-off screed, behind the blade or screw, has its bottom elevation controlled by the operator and is usually set somewhat higher than the desired finished elevation so that after consolidation the surface will have the correct elevation. A controlled excess of fresh mix should be kept ahead of the spreader to avoid starving the strike-off screed and any abrupt change in the elevation of the strike-off screed must be avoided.

Segregation may occur at the sides adjacent to forms or contact joints which will produce rock pockets because of insufficient mortar for proper consolidation. If this segregation cannot be corrected by adjustment of the equipment or its operation, it may be necessary to place fresh concrete against the forms by hand in advance of the spreader operation. Operations which result in rock pockets must not be permitted and wherever rock pockets have occurred these must be repaired where necessary by the contractor and at his expense.

B. Tamping and Screeding

The tamping-screeding finisher should closely follow the spreader so that the mix is tamped and shaped to desired cross section before any hardening of the concrete takes place. Also, the spreader operator, in practice, observes the size of the roll of excess concrete at the front screed of this machine to judge the proper elevation adjustment of the spreader strike-off screed.

Adjustments must be made by increasing or decreasing the elevation of the screeds in relation to side forms to compensate for variations in superelevation or cross slope. Such changes should be anticipated by the operator and accomplished by small increments. Individual corrections should not exceed a half turn of the adjustment screws. More abrupt changes result in variations in the surface elevation which delay and reduce the efficiency of subsequent finishing. Normally, the front screed on this machine is tilted down slightly so that the leading edge is 0.01 to 0.03 foot below the trailing edge. The rear screed is tilted up slightly so that the leading edge is approximately 0.02 foot above the trailing edge.

Proper elevation and cross slope for the screeds of this finisher are determined through the use of a straightedge laid across the pavement and side forms after the final pass. The surface of the fresh concrete should be above the plane of the side forms by an amount sufficient to provide for slump and subsidence during finishing which varies with different mixes. Experience with the mix in use will indicate the most satisfactory settings.

The tamper bar should be adjusted so that it penetrates approximately 0.03 foot into the fresh concrete at the bottom of its stroke.

Usually two passes of the tamping-screeding finisher are adequate to tamp and shape the pavement surface. There are occasions, however, when additional passes become necessary. The number of passes necessary can be judged by observing the uniformity of the roll of excess mix carried on the rear screed as the machine operates. This roll of material should be only a few inches high and be reasonably uniform across the full width and should not vary appreciably during the entire final pass.

Tamping-screeding finishers should be provided with adequately maintained scrapers at each wheel to prevent intrusion of mix between them and the top of the forms.

C. Preliminary Finishing

This operation consists of floating away irregularities in the surface left the spreading and screeding operations, irregularities produced by differential subsidence in the concrete and porosity or tears in the surface.

Bumps and other deviations remaining in the surface after spreading and screeding must be cut and floated out as early as possible while the concrete is still very plastic and workable. Initial passes of float finishers should therefore follow immediately after the tamping-screeding finisher, and should be performed as rapidly as possible. The roller should be used extensively during this operation to work rock particles back into the mix structure and produce a well knit surface.

Irregularities produced by differential subsidence of the concrete must be floated out as late as possible so that additional subsidence will not occur. The timing of this work is from 1½ to 2 hours after placement of concrete in warm, dry weather. Cool and damp conditions will extend this time. Normally, floats are lowered by increments to approximately 0.1 foot above finish grade during initial passes of this finisher. The remaining adjustment to finish grade is made by increments during the final finish passes of the equipment. Manipulation of the surface of the concrete during the period of greatest bleeding, if there is free water present, should be held to a minimum. Floating or screeding the surface in the presence of excess water results in leaching the cement which produces low strength surface mortar of inferior abrasion resistance and durability. The roller on float finishers can be used effectively in eliminating pockets or puddles of water on the surface during the bleeding period. It is well to remember that float finishers can be "over used", that is, an excessive number of passes of a float can be made resulting in an undesirable quantity of low strength mortar on the surface.

Water should be added during float finishing only to maintain proper moisture for adequate curing. Adding water to make more grout for floating is poor practice. Generally, the difficulty in floating is caused by too much delay in the finishing operation, and the finish floating should be performed earlier.

Float finishers should be provided with adequately maintained scrapers at each wheel to prevent intrusion of mix between them and the top of the forms.

D. Final Finishing

The final finishing operation normally consists of tooling all edges and producing the required surface texture.

Edging should be performed concurrently with preliminary finishing with a final pass of the tools made after all floating operations are complete and the concrete has become firmly set.

Edging tools should be operated so as to avoid deforming the pavement surface except for the desired edge rounding.

Surface texturing with a burlap drag should follow all other finishing operations so the entire width of pavement surface is uniformly finished. The burlap drag must be of multiple-ply, at least three feet in width and be long enough to cover the width of the pavement slab.

E. Joints

Wire mesh, bar mats or continuous reinforcing is not often used on Montana's recent concrete pavement but when these materials are required they should be kept clean and undamaged before use and be free of dirt, oil, paint, grease and excessive rust when placed.

1. Dowell supporting assemblies, when required for transverse joints must be laid out and marked in such that the exact centerline of the assembly can be re-established. Generally they are held in correct position by the use of metal stakes or pins that are left in the pavement. Small wires used for holding dowel supporting assemblies together during fabrica-

tion and shipment should be cut after installation. Dowels should be free moving with an approved dowel cap or sleeve in place and coated with asphalt MC-70 or other approved lubricant.

2. Tiebars installed across the centerline should be parallel to the surface and at right angles to the centerline. Unless an approved mechanical device operating immediately behind the spreader, or behind the strike-off for slipform paving, is used for the installation, they must be installed ahead of placing the concrete and held securely in position.

3. Expansion joints should be placed at locations and by methods shown on the plans and as required by specifications.

4. Keyways for multiple lane paving must be held in proper position against the face of the roadway forms. Tiebars or hook dowels must be correctly spaced and securely fastened.

5. Sawing, when required or permitted by the contract is to be accomplished as soon after the concrete has hardened as can be done without tearing or raveling and before random, uncontrolled shrinkage cracks develop. Procedures that cause premature cracking are to be immediately revised by adjusting the sequence of cutting or the time interval between placing the concrete and sawing it.

   The four factors exerting the greatest influence on the success of sawed joint construction with diamond blades are:

   (a) Peripheral speed of the saw blade,
   (b) Hardness of bond of the cutting medium,
   (c) Rate of advance of saw blade through the concrete,
   (d) Timing of the joint sawing, and
   (e) Depth of cut.

   All of these factors are the responsibility of the sawing contractor; however, their effect on the success of this method of joint construction warrants some discussion in this manual. Optimum results can only be achieved by the trial and error method of varying each factor independently, adjusting the speed of the drive mechanism and trying different saw blades until the best combination is achieved, or by utilizing prior experience with the particular quality of aggregate contained in the concrete.

   The last factor, though controlled within general limits by the specifications, must be specifically determined by the engineer on the basis of the degree of curing and the cracking tendency of the concrete at different intervals in the age of the concrete.

   With the improvement achieved in the manufacture of diamond saw blades since their initial application to concrete pavement construction, green concrete can often be sawed as successfully as well-aged, hardened concrete. The proper time to saw weakened plane joints, however, varies widely from 10 hours to many days after the concrete is placed, depending upon the function of the particular joint and upon the condition of the concrete. Control joints, because of their function to relieve early drying-skrinkage stresses, must be cut as soon as the concrete has hardened enough to support the saw equipment, providing that cutting does not disrupt the concrete. It is generally not considered practical to attempt construction of control joints at night. Should night interrupt control joint sawing and conditions do not demand immediate completion, the work should be resumed during daylight hours the following day and be completed before the concrete reaches an age of 24 hours.

The proper combination of blade type and rate of sawing is particularly important when sawing control joints because of the lack of strength and extreme greenness of the concrete.

Intermidiate joint sawing is delayed for at least 24 hours to allow the concrete to develop additional strength to better resist sawing stresses. Excessive raveling at the top edges of the saw cut and washing of mortar from the faces of the cut under the action of the saw indicates that the cut is being made too early, or that the combination of peripheral blade speed and hardness of bond are incorrect for aggregate in use. In the latter instance, instead of cutting cleanly, the saw blade becomes glazed and plows rather than cuts.

Slight raveling of the top edges of a saw cut, with excessive washing of mortar from the faces of the cut and loosening of aggregate particles, clearly indicates that the combination of peripheral blade speed, hardness of bond and rate of advance of blade are incorrect.

The correct combination of blade bond and speed will result in the cleanest cut and the greatest blade life in terms of footage per blade.

After stresses in the concrete develop to the level of causing volunteer cracks, the slab is in tension and further sawing will result in cracks ahead of the saw cut. When these conditions are encountered, the sawing should be discontinued until the following morning when temperature rise relieves the tensile stress, or if daylight hours remain and the concrete is sufficiently hardened, the sawing operation should be moved ahead into concrete of a younger age in which stresses have not yet reached a point where volunteer cracking results.

6. Sealing joints with approved joint sealer materials is to be done before opening to traffic and after the joints, whether sawed or formed, have been thoroughly cleaned and are surface-dry. Heated joint material, if used, must be stirred to avoid localized overheating and must have its temperature checked continually to

assure compliance with the manufacturer's recommended temperatures. Joint sealer poured into the joints is to be done carefully to avoid spillage on the exposed concrete surface and must be restricted to application when the air temperatures are higher than 50° F. Be sure to scrap excess sealing material from the slab.

51.05 Surface Test

The hardening concrete surface is to be checked with a 10 foot straightedge as soon as possible after the concrete has set. All irregularities showing a total variation of more than 1/8 inch in 10 foot are to be corrected by grinding the bumps and properly patching low spots to fit the template.

51.06 Curing

After finishing operations have been completed and as soon as surface marring will not occur, the entire width of the pavement should be cured. Timing of the application of curing material is extremely important and must be done prior to the time the surface dries out to avoid shrinkage cracks. Various methods of curing are used such as cotton or burlap mats, waterproof paper, impervious membrane, polyethylene sheeting and other approved methods.

A. Burlap or cottom mats must be dampened prior to placement on the pavement and shall be kept thoroughly wet throughout the curing period. The mats are to be placed and weighted so they will remain in contact with the surface.

B. Waterproof paper and polyethylene sheeting must cover the entire surface and be weighted to avoid displacement. It might be necessary to sew or cement joints in the paper or sheeting. The surface of the pavement should be thoroughly wetted by means of a fine spray prior to placement of the curing material.

C. Impervious membrane is to be applied uniformly with fully atomizing, tank agitator type spraying equipment at the rate of one gallon to not more than 150 square feet. Frequent checks should be made and recorded of the quantity used in relation to surface area to insure proper rate of application. Should the curing agent be damaged by rain or other causes, the damaged membrane must be repaired immediately by an additional application.

51.07 Removing Forms

Removal of side forms requires good judgment, since weather and temperature will affect this operation. Unless sawing is necessary before concrete has set for at least 12 hours, the forms shall not be removed before this length of time. In all cases, the concrete should have hardened to the extent that spalling or other damage will not occur. Immediately upon removal of forms all honeycomb must be patched and the pavement edges cured in an approved manner.

51.08 Slip Formed Concrete Pavement

For slip-form pavement, the construction of the pavement base is distinctly a separate construction operation and is generally performed more in advance of paving than in side-form construction. Frequently, all of the base for pavement is completed before the outset of concreting.

A. Pavement Base

Because of absence of side forms from which control of elevation for the surface of both pavement and base can be taken, accuracy and uniformity of profile and cross section of the base surface are more critical in respect to thickness of pavement and quantity of concrete.

Also, because of the absence of side forms, the base for slip-form pavements is much more frequently used as a trafficway for for contractor and other vehicles and equipment. Consequently, risk of damage to the base, and more particularly the asphaltic curing seal, is increased and the importance of checking fqr damage immediately before concreting is more pronounced. Furthermore, use of the pavement base by batch trucks and mixers, results in the accumulation of dust and other contaminants. This condition must be corrected immediately before placing concrete. It is usually satisfactory for the contractor to shovel away loose material, such as spills at the mixer skip, and to dampen the base with water after the mixer has passed by to offset the drying effect of the dust.

In hot, dry weather, it is also advisable to cool the subgrade for slip-form pavement with water as discussed in the construction details for side-formed pavement construction.

Specifications for slip-form pavement construction require that no high subgrade be permitted. Compliance with this provision should be carefully checked to avoid construction of less than specified depth of pavement concrete. The elevation of the completed subgrade can be readily checked at staked intervals with levels, templates, etc. The elevation of the completed subgrade at intervening locations along line must also be checked to determine that no high subgrade exists.

The amount of low subgrade directly affects the amount of overrun in concrete quantity. Thus, the condition and extent of low subgrade should be clearly recognized and this information made available continuously to the contractor so that he will be enabled to intelligently control his operations, and to assure that required thickness of base is obtained.

B. Grade of Track Paths

When non-automatically controlled slip-form paving is used, the condition of the grade for the track paths of the slipform paver will affect the final profile and cross section of the pavement. Therefore, the track paths must be carefully prepared, checked and maintained by the contractor in a smooth and compacted condition until the pavement is constructed. Frequently, in the vicinity of structures, some handwork is necessary and occasionally it has been found expedient to correct deficiencies in the grade of the track paths by hand placed and compacted asphaltic concrete.

The condition of the track paths is less critically reflected in the completed pavement surface when automatically controled slip-form paving is used. Here, the preset control wires are the primary control of grade. Nevertheless, a reasonably smooth and compact subgrade in the track path is necessary for optimum finishing results. Major irregularities in the grade of the track paths may be reflected in some loss of pavement smoothness.

C. Control Guide Wires

The guide wires, controlling the slip-formed pavement grade, perform a function similar to that of side-forms used in conventional concrete paving. The pavement surface can be no more smooth or true in cross-section than the accuracy to which the control wire has been set and maintained. The wire, when installed should be carefully checked against the survey stakes for alignment and grade. It should be firmly held in the brackets from which it is suspended and must be uniformly tight, free from kinks, bends, obstruction and appendages such as flagging, etc.

Sixteen or eighteen gauge piano wire is usually used for the guides. It should be tensioned so that there is no measurable sag between supporting stakes.

A final check and adjustment of the wore should be made immediately before paving by sighting along the wore to detect and eliminate any irregularities in line and grade.

D. Placing, Spreading and Finishing Slip-Formed Concrete Pavement

Slip-form machines are designed to receive concrete either on the subgrade within an extension of the attached side forms or in a receiving hopper. Hoppers, when provided, serve the purpose of laterally distributing the fresh concrete to the main screed. Concrete discharged into such a hopper should not fall more than 5 feet, otherwise segregation will occur and the mix will also surge under the screed.

When concrete is placed on the subgrade in advance of the slip-form paver, it is very important to provide a uniform quantity of concrete for the strike-off blade. Piles of dry concrete cause the paver to "float" or lift above the true elevation which results in a high area.

Consolidation of slip-formed concrete is accomplished by use of vibrators mounted to protrude into the mass of concrete. Vibration frequency is critical and must be frequently checked to assure uniform consolidation is being accomplished. Multiple speed vibrators when used, are to be mounted at approximately 2.5 foot centers with the outer vibrators no closer than 0.5 feet from each edge of the pavement.

Preliminary finishing and shaping is accomplished through the action of the primary screed which is rigidly attached to the main frame of the paver. The main screed may be installed with a fixed allowance for crown. Devices providing a variable crown adjustment have generally proven unsatisfactory. Concrete has a tendency to slump at the edges of the pavement after passage of the final section of the trailing forms. One method of compensating for edge slump involves the shape of the primary screed which is manufactured so the outer portion, adjacent to the pavement edge, is tapered upward thus shaping the edge of the pavement surface slightly higher than the plane of the finished surface. After passage of the trailing forms, the edges subside to the desired plane. However, different concrete mixes and especially water content have a marked effect on the amount of correction available in this method. Concrete having a slump of 1½ to 2 inch, has been successfully molded, at the pavement edge, by providing a uniform taper varying from 0.04 feet high at the edge to zero at 0.5 feet in from the edge.

Another method of compensating for edge-slump involves adjusting the width of the side and trailing forms so that a uniform convergence, from front to rear is achieved. Concrete deposited at the wider part of the form, in front, is thus squeezed upward above the plane of the finished surface by the narrowing side forms. Edge-slump after passage is expected to compensate for the increased edge height by restoring this edge to the elevation of the finished surface. Adjustments can be made during operation to accomodate variable mixes. The squeezing action of the forms can cause segregation at the edges so that grout is worked down and under the forms, requiring more handwork in finishing the edges.

E. Final Finishing

The final finish is produced by means of a secondary ironing screed, followed by an oscillating belt and a Vee-shaped, free floating, smoothing float. (or a 1" diameter soft rubber nose dragged the full width of the pavement, followed by a combination self propelled float and burlap drag.) In lieu of this equipment, tamping bars followed by an extrusion plate and a transverse reciprocating belt are used.

The sliding forms attached to the paver must be rigidly held together laterally to prevent spreading. They shall be of sufficient length so that no appreciable slumping will occur and any necessary hand finishing can be accomplished while the concrete is still within the forms. Checking of the surface and texturing are performed in the same manner as required for formed pavement. The final burlap drag should be done after all other finishing operations are complete.

51.09 Bump Cutting Hardened Concrete Pavements

Bump cutting pavement surfaces after the concrete has hardened, where necessary for conformance with tolerances as measured by straight edge checking is best performed with a machine employing multiple diamond saw blades mounted on a transverse arbor.

This equipment is operated after the concrete has aged several days and is well hardened.

A straightedge is used to accurately define the bump and a cutter is then operated over the bump moving parallel with the centerline.

Measurements taken on the pavement surface with a straightedge will determine the approximate depth of grinding necessary at any given area requiring grinding. The elevation of the cutting head is then adjusted in elevation during grinding so that the depth of cut equals the required depth of grinding. Following this procedure each time, the bump cutter is operated repeatedly across the bump with parallel adjacent cuts until the entire area of the bump has been reduced. A straightedge should be used repeatedly during the operation to check the depth of cut and uniformity of final profile. The grinding should be repeated until the specified tolerances are met.

51.10 Protecting the New Pavement

In areas where vehicle, pedestrian or animal traffic can reasonably be expected, adequate preventive devices should be provided by the contractor to protect the new concrete pavement from damage.

The following methods and devices may be used for this purpose: Barricades, earthen windrows and proper signing are installed wherever vehicular traffic is accustomed or likely to attempt passage. Pavement constructed along areas in use for parking are vulnerable to damage unless positive deterrents are used. An earthen windrow thrown up adjacent to the edge of the new surface effectively blocks vehicular traffic.

Barricades with proper signing are occasionally effective where a new pavement adjoins or extends an existing trafficway. Consideration should be given to constructing an earthen windrow or asphaltic curbing in these cases as insurance against expensive and undesirable repair of areas in the new concrete caused by accidental or irresponsible operation of vehicles despite the warning and obstruction of barricades.

Obviously, such protective devices apply to vehicles owned and operated by job personnel, contractor or State.

Protection against damage by pedestrians or animals is much more difficult. Advance planning for a paving operation includes consideration of the construction of permanent fences prior to start of concreting. Where permanent fences cannot be constructed in advance of paving or where there are no fences to be built, consideration should be given to constructing temporary railings or fences across normal animal trails or pedestrian walkways. An alternate in the case of pedestrians is to provide temporary crossovers to allow foot traffic to cross the cresh concrete at reasonable and obvious intervals.

51.11 Opening to Traffic

The completed pavement is not opened to traffic until it has attained a compressive strength of 3500 pounds per square inch when tested by AASHO T-22. All longitudinal joint must have been completed and the edges protected by permanent shoulders or temporary earthen material compacted against the pavement edges.

Prior to opening to traffic, the pavement should be cleaned, properly signed, marked and cleared of all obstructions making it safe for the traveling public.

51.12 Tolerances In Pavement Thickness

Prior to final acceptance, the pavement is to be core drilled with at least two cores taken for every 1000 linear feet of pavement and these cores measured by the average caliper measurement in accordance with AASHO T-148. If pavement thickness is not within the allowable tolerance, deductions for deficient pavement will be made in conformance with the contract requirements.

Store the cores removed from pavement in a suitable location so that the contractor and other interested parties may observe them and check the measurements.

51.13 Inspection Reports, Records And Diary

A. Plant Inspector

All required records and reports are to be current and prepared in conformance with instructions. All test reports are to be dated and signed by the person making the test. An orderly record should be kept of all specific checks or tests made to determine compliance with specifications such as:

All calibrations, verifications and checks.
Accumulative total of all acceptable materials received.

Moisture Tests
Scale weight settings
Accumulative total of material used
Flexural test results.

A Diary, in addition to the Resident Engineer's project diary, must be maintained by the plant inspector and should be a concise record of daily events and observations of the inspector. This record should include: All special instructions to the contractor, unusual action taken by inspector, daily time of starting and ending operations and extent of progress by stations, lost time due to breakdown or other reasons, contractor's forces, weather and temperature conditions. All entries must be dated and identified by the signature of the writer.

B. Slab Inspector

All required records and reports should be kept current and prepared in conformance with instructions: All test reports should be dated and signed by the person making the tests. An orderly record should be kept of all specific checks or tests made to determine compliance with specifications, such as:

Subgrade measurements
Check of mixer timer
Check of impulses or strokes of vibrators or tampers.
Record of water used at on-site mixer.
Record of equipment checks and adjustments.
Slump and entrained air tests.
Depth of reinforcement.
Check of finished crown and straightedging.
Check of curing application.
Check of depth and width of sawed joints.

A Diary must be maintained by the road inspector and should be a concise record of daily events and observations of the inspector. This record should include: All special instructions to the contractor, unusual action taken by the inspector, daily time of starting and ending operations and extent of progress by stations, lost time due to breakdown or other reasons, contractor's forces, weather and temperature conditions. All entries must be dated and identified by the signature of the writer.

IV - 52 Reinforcing Steel

52.00 References

Standard Specifications - Section 47

52.01 General

Reinforcing steel consists of steel bars or wire fabric furnished and placed into concrete structures for added strength. This steel comes in various types and sizes. It is bent to fit various shapes or it may come in straight sections.

Reinforcing steel is particularly designed to accept and transfer the various forces of impact, shear and bending that are imposed on the concrete. For this reason, it is extremely important to make sure that it is right. Clearance from the forms, bar size, lapping details, type of bend specified, method of tying the steel and how the steel is supported are critical. Changing any of these details can seriously change the design and safety factor of the structure.

52.02 Materials and Inspection

Reinforcement, arriving on the job before needed, should be stored to prevent bending, rusting or gathering of oil. Check the re-steel before it is placed in the structure, to see if it is free from dirt, scale or excessive rust, paint, oil or similar matter, which might prevent bonding between the steel and the concrete. How excessive dirt, rust, scale, paint or oil is removed is the contractor's problem, but if the foreign matter appears excessive, it must be removed. Heavy rust-pitted steel must be rejected because the loss in cross-section area will cause the steel to be overstressed.

Steel bars shall be tied or wired in place and supported on metal chairs and so secure that when concrete is placed the steel will not sag or be displaced. The correct clearance is usually shown on the plan sheets, but if it is not shown, make sure there is at least two (2) inches of concrete to the edge of the outside bars. If bars are placed too near the surface of concrete, particularly where water and de-icing chemicals can penetrate concrete, the steel may rust. Steel expands when rusting, then concrete spalls off. Spalling would soon destroy the surface, causing an unsightly product, costly maintenance, and loss of pride in the constructed product.

Steel bars protruding from concrete exposed to weather for several months, are to be protected to prevent rust. Don't allow rust preventative coatings to remain on steel when concrete work begins. They may prevent bonding of concrete to the steel. All reinforcing steel has to be firmly secured and in its proper position before the placement of concrete. Any splices of steel bars not specifically shown on the plans must have prior written approval. Replacing one-piece steel with short sections spliced together should not be allowed. Do not permit welding of steel bars unless specifically stated in the plans or special provisions.

Anything desired by the contractor but not specifically mentioned in the Standard Specifications, the special provisions or the plans needs written approval before use. Written approval to change any detail of the reinforcing steel must be obtained from the Division Engineer who will need to check with the Bridge Engineer first.

In accordance with all previous instructions, it has been the standard procedure that:

1. The contractor shall place and tie the reinforcing steel in the correct quantity and position as shown on the plans and in compliance with the Standard Specifications.

2. When the contractor has completed his work, the inspector shall check the reinforcing steel placement to see that all clearances, bar spacing, tying, bar lap and the quantity of bars placed are as called out on the plans and in accordance with the Standard Specifications.

3. The inspector shall be completely satisfied that all the requirements of Items No. 1 and 2 above have been complied with before he allows concrete to be placed around the reinforcing steel.

52.04 Records & Documentation

A record of inspecting the reinforcing steel as portions of a structure are constructed is to be made in the notes (for large projects) or in the diary (for minor structures). The record should show date of inspection, inspectors name and portion of the structure inspected.

The inspection should reveal any inaccuracies, unacceptable practices, wrong bar sizes, improperly bent steel, loose ties, wrong clearances, oil or other foreign matter on the bars or steel that might be moved out of position when concrete is placed. Naturally wrong things are to be corrected before concrete is placed.

A sample "Record of Reinforcing Steel Inspection" is on Figures IV-12 and 12(A) for use as a guide in preparing this record for all future work. Please note that this record has been set up in an attempt to match what could be anticipated as a typical concrete placement sequence for a project.

This record shall be kept current for each structure in the same manner as is required for the project concrete cylinder records. (Concrete Diaries).

The "Record of Reinforcing Steel Inspection" shall be made a part of the "Final Pay Quantity Books" and submitted with the Final Estimate.

IV-55 Excavation For Culverts and Minor Structures

55.00 References

Standard Specifications - Section 52, Standard Drawings for culverts.

55.01 General

The purpose of this section is to give new men some of the basic ideas of culvert inspection and to standardize as much as possible our Measurement and Construction procedures for everyone. No manual can replace experience. New men will need training and supervision but the manual can be a reference place for answers to some of their questions.

55.02 Inspection

When construction is to begin the culvert inspector should have the culvert book available to check that the stakes are marked correctly. If the culvert is in a fill area, check that inlet and outlet elevations match the flowline of the channel that the culvert intercepts. If the section is cut, check to see that the inlet and outlet elevation match the ditch line grade.

55.03 Traffic Control

Before doing any excavation for the culvert find out how the contractor expects to handle traffic. When a detour is needed, be sure it is well signed. If it is so rough that traffic must slow to under 35 M.P.H. use flagmen to direct traffic through the construction area. Detours should be eliminated as soon as possible because they are usually hazardous and irritating to traffic.

55.04 Excavation

The rough grading is usually done with a bulldozer, dragline or front-end loader and it is during this excavation that the soil is better exposed for examination than at any other time. This is the time to decide whether the culvert bed will support the pipe or whether subexcavation will be needed.

Some of the problem soils or situations that can require subexcavation or special treatment are listed below.

1. Swamps

Material in swamps is often an organic silt or clay that has little or no strength when wet, and almost always requires subexcavation and backfilling with a gravel or sand bedding material.

Sometimes the culvert can be moved to a more stable location, a steel probe can be used to help in finding a firm bottom. Usually the edge of a swamp is more stable than locations near the center.

In cases where the culvert cannot be moved or it takes too much subexcavation to find a firm foundation, remove enough of the muck to provide a reasonably stable bed. In the worst areas this may take from three (3) to six (6) feet.

2. Rock

When excavation uncovers rock or clay hard pan, the specifications require that it be subexcavated one (1) foot deep. If during excavation soft and hard spots occur in the foundation, it should be subexcavated for at least a foot so that the pipe will be supported evenly. The material used for backfill can be gravelly material or a reasonably imperious clay.

3. Silt and Fine Sand

There are some silts and very fine sands that water flows through easily. In these soils the water will flow under and around rather than through the culvert, a condition known as piping. A good way to check for potential piping is to examine older culverts in the area, and to check with the local maintenance section man. If piping is a problem the section man will have had continuing maintenance of the old culverts, and he may have useful suggestions for solving the problem.

Subexcavation is usually not satisfactory. The best form of protection is a cut-off wall at the inlet and outlet of the culvert.

4. Chemical in Soil

A heavily alkaline or acidic soil can destroy a culvert by its corrosive action, therefore, the soil is tested for its chemical nature during the preliminary soils survey. However, retesting may be necessary in suspect areas if the culvert was relocated during design or construction.

Heavy alkalinity, which is common in Montana, usually shows up as a heavy white deposit left in places where water has concentrated and later evaporated. The acid condition, although not as common, is found in drainage from mines, decomposed organic material on heavily timbered mountain slopes or in swamps. Observe the pipe removals on the project, if the pipes that you remove are badly corroded, it is usually due to an active chemical in the soil.

The Division Soils Laboratory can tell you whether the location was tested and the test results. In case the pipe location has not been tested the Division Lab will send a sample to Helena for testing. The type and intensity of the chemicals in the soil can be determined and a pipe that will resist corrosion can be used, if necessary.

55.05 Grade Stakes and Hubs

After the rough grading is completed, hubs can be set to grade at the ends of the culvert. Elevations for grade can be established by leveling from a bench mark or from the offset hubs set by the staking crew.

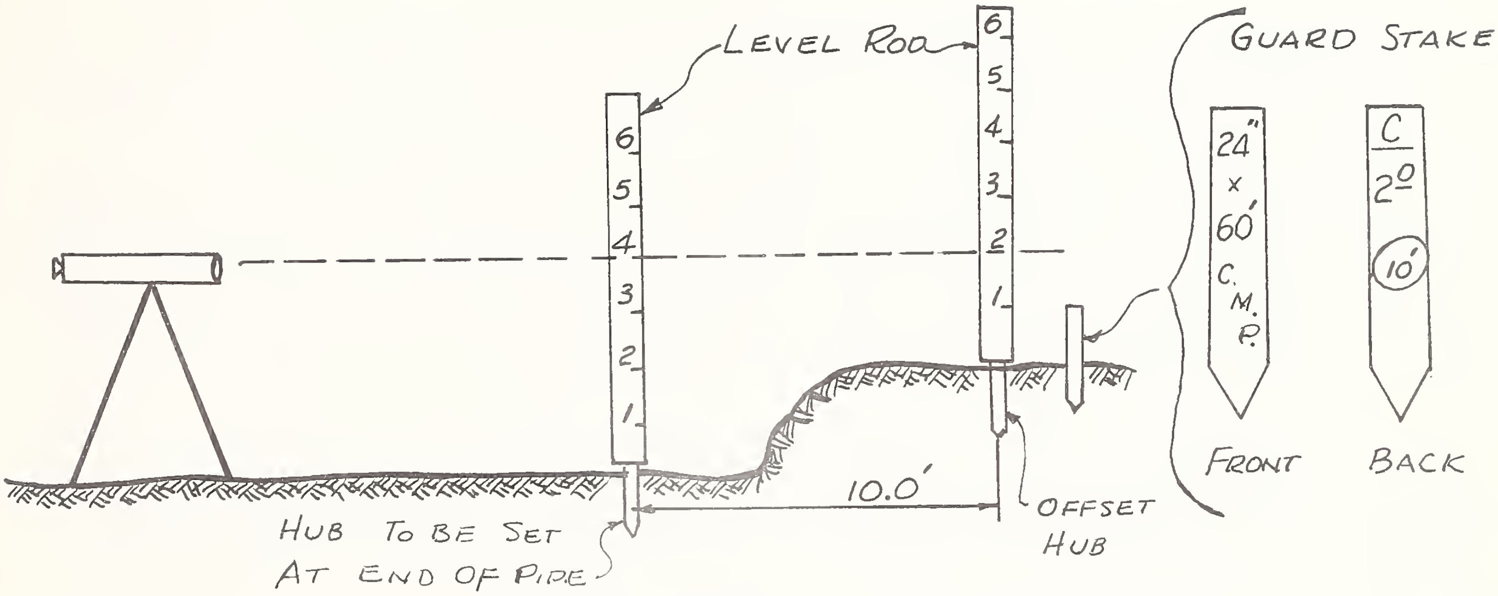


FIGURE I

In the above illustration the rod is placed on the offset hub and sighted with either a hand level or a regular level. The reading is 2.0. The rod is then moved ten (10) feet to the new hub at the end of the culvert, and the hub driven into the ground until 4.0 is read on the rod. The elevation of the new hub will be the flow line of the culvert. For concrete pipe set the elevation of the bed one shell thickness lower. By sighting from one offset hub to the other for alignment, the hub at the other end can be set. Check the difference in elevation of the two hubs to see that they agree with the difference shown in the culvert notes. The contractor can now do his "fine grading" by setting a string line some convenient distance above the grade line.

55.06 Compaction

The contractor may use regular compaction equipment, such as sheepsfoot, vibratory or rubber tired roller, before he shapes the bed. However, it is hard to get the proper compaction of the shaped portion of the bed without hand equipment. There are several types of hand compactors in use now, "turtles", "whackers", and hand pneumatic tampers, that will give good results.

Specifications require that the culvert bed be uniformly compacted to 95% of maximum density unless there is a good reason for not getting this much density. At least one passing compaction test is required at each culvert bed for documentation. But this test or tests should not be a blanket approval of the entire bed, rather the results should be used as a guide for the inspector to judge when compaction is satisfactory. If the density requirement has been waived the reason should be recorded in the culvert book for documentation.

Some inspectors poke a stake or steel rod into the ground at the site of a passing test and use the resistance as a rough guide to check for corresponding resistance at random locations on the culvert bed. Doubtful areas can be compacted more, or tested if the contractor doubts that poking a stick is scientific enough.

The main idea is to get a uniformly compacted bed and this can seldom be accomplished with testing alone. The inspector will have to use good judgment to supplement his tests.

Although specifications do not require optimum moisture of the culvert bed, adding water will speed up compaction in difficult areas. Insist on the required compaction before placing any pipe but how the contractor gets it is his business. A good bed is half the battle. It will support the pipe evenly without settlement. A poor bed will settle unevenly, causing water to pond inside the pipe, uneven loading and possibly complete failure of the pipe.

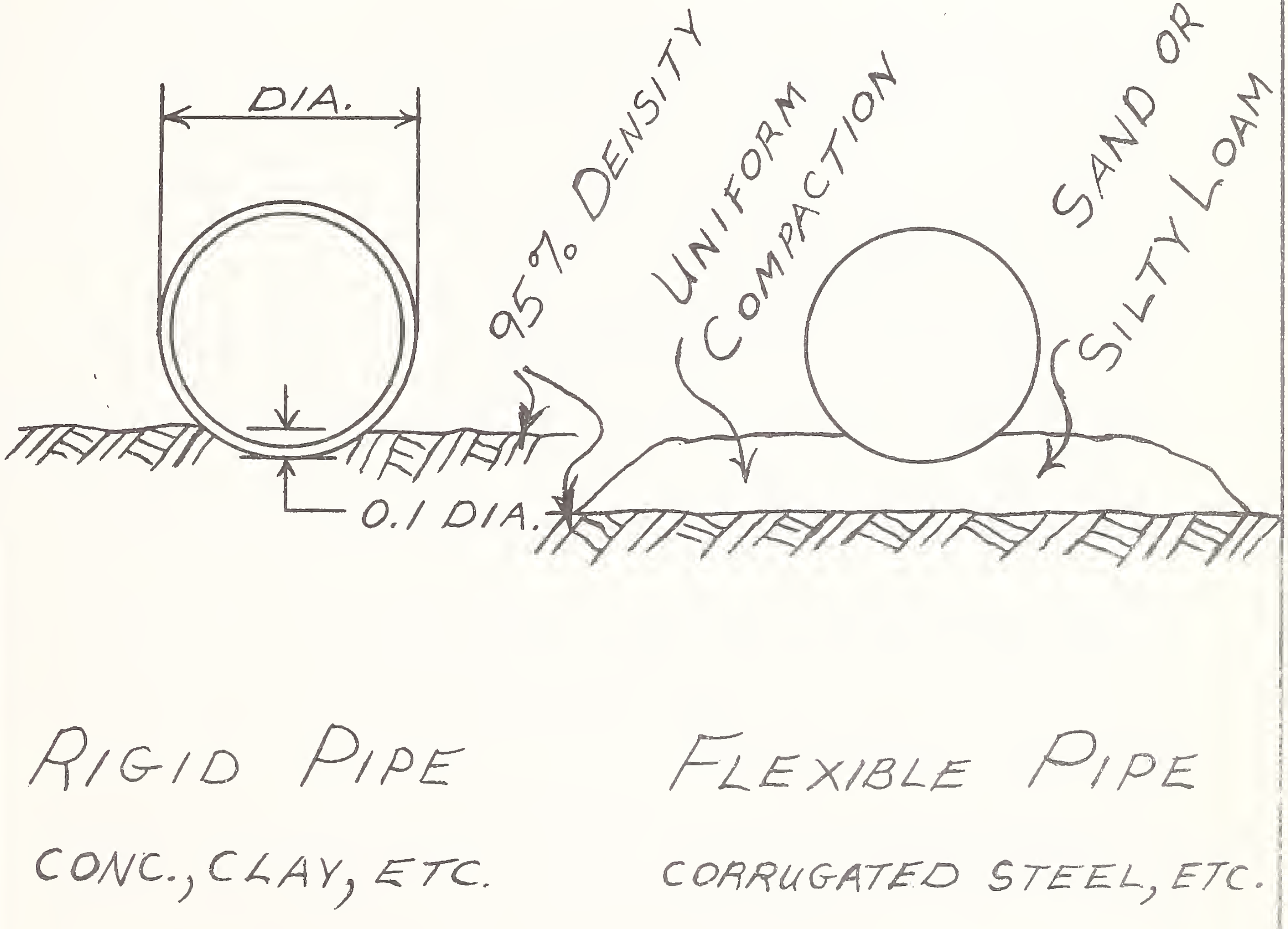
Wet installations that require bedding material to get a stable bed sometimes cannot be compacted to full density. Compactors may cause water and muck to start pumping through the bedding material and will do more harm than good. Fortunately well graded bedding material will achieve a reasonable density without a lot of compaction.

55.07 Measurement Culvert Excavation and Bedding Material

A. Culvert Excavation

Measurement for payment of culvert excavation is based on cross-sectional area of the culvert and the width of bed needed. The measurement although not complicated, can become confusing. Probably the easiest way to explain the measurement is with sketches and some examples.

SHAPING & COMPACTION



Specifications for all rigid pipe larger than a 12 inch diameter require Class "C" bedding, as shown on Standard Drawing No. 54-01, unless some other method is specifically called for on the plans or special provisions. A Class "C" bed is shaped to fit the pipe for a depth of 1/10 the diameter of the pipe.

A more thorough explanation for bedding flexible pipe is shown on Standard Drawing No. 54-06.

FIGURE 2

Example for Figure 3

The material at most sites is satisfactory for the foundation, bed and backfill. Figure 3 is representive of most culvert installation and illustrates most specification requirements for measurement of culvert excavation

1) Measure the area of material between the bottom of the culvert and the ground line or the subgrade template, which ever is lower. From point (1) to (2) and from (3) to (4), the ground line is below the template and therefore, the area measured is between the ground line and the bottom of the pipe.

   However, from (4) to (5), measure the area between the template and the bottom of the pipe. Here the template is lower than the ground line and measurement is based on template regardless of whether the dirt is taken out before, during or after installation.

2) From point (2) to (3) the ground line drops below the bottom of the culvert. This area is fill and is not measured for payment.

3) The pay width for culvert excavation in stable, dry locations is the outside diameter plus one foot on each side of the pipe. The contractor might excavate wider in such stable locations, usually because his equipment is too large to excavate narrow trenches, but no extra width is measured for payment.

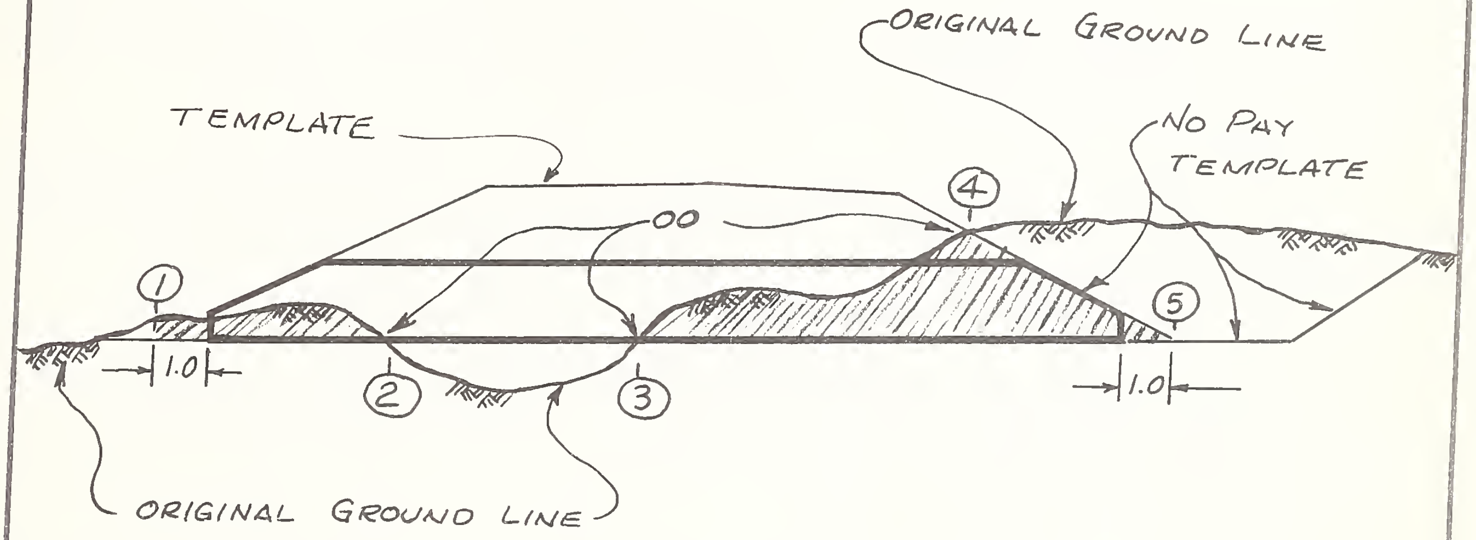
   A pay width greater than one foot on each side of the pipe can be allowed in special cases, when a wider bed is directed to be excavated. Here the pay width for culvert excavation should be no greater than six (6) feet on each side of the pipe. Pay widths from two (2) to six (6) feet on each side of the pipe are unusual and a full explanation should be written in the culvert book.

From points (1) to (2), and (3) to (4) to (5) the pay area is computed with a calculator the same as an end area. The ground line, template and bottom of the pipe can be plotted on cross-section paper for picking the distance and elevation of the 00's. The volume will then be this cross-sectional area times the width.

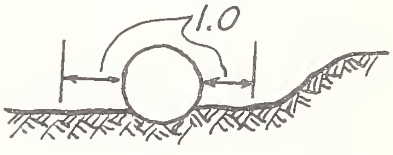
Find the volume of culvert excavation for Figure 2 using a 48" x 60' R.C.P. Culvert with the following information.

A = end area (1) to (2) + (3) to (4) to (5) = 100 square feet.
W = width = outside diameter (From Std. Drg. No. 62-01) + 2.0 ft. = 4.83 ft. + 2.0 ft. = 6.8 ft. Notice that no additional width is allowed for the flared end section. The regular width of 6.8 feet is used for the full length of the pipe straight through the flared end section.

$$V = A \times W = \frac{100 \text{ sq. ft.} \times 6.8 \text{ ft.}}{27 \ \frac{\text{cu. ft.}}{\text{cu. yd.}}} = 25.2 \text{ cu. yds.}$$



NOTE:
SHADED PORTIONS REPRESENT THE PAY AREAS



END VIEW

ORDINARY INSTALLATION

STABLE FOUNDATION

FIGURE 3

Example For Figure 4

Figure 4 illustrates a pipe that needs additional support but the material at the culvert end is good enough to use as a plug for the last ten (10) feet. This method is used for pipe with diameter over 54 inches and for multi-plate installations. The purpose of the plug is to prevent piping under the culvert.

The area measurement for culvert excavation is from (1) to (2) and from (3) to (4) using the same rules as in Figure 3. Notice that the channel change measurement is started one (1) foot from the end of the culvert rather than at the culvert end or continuing through the culvert.

Don't consider channel changes as template in an effort to reduce the culvert excavation unless the contractor can reasonably be expected to take the channel out with regular equipment. Any channel change less than 12 feet wide is difficult to work, and should begin or end one (1) foot from the pipe ends.

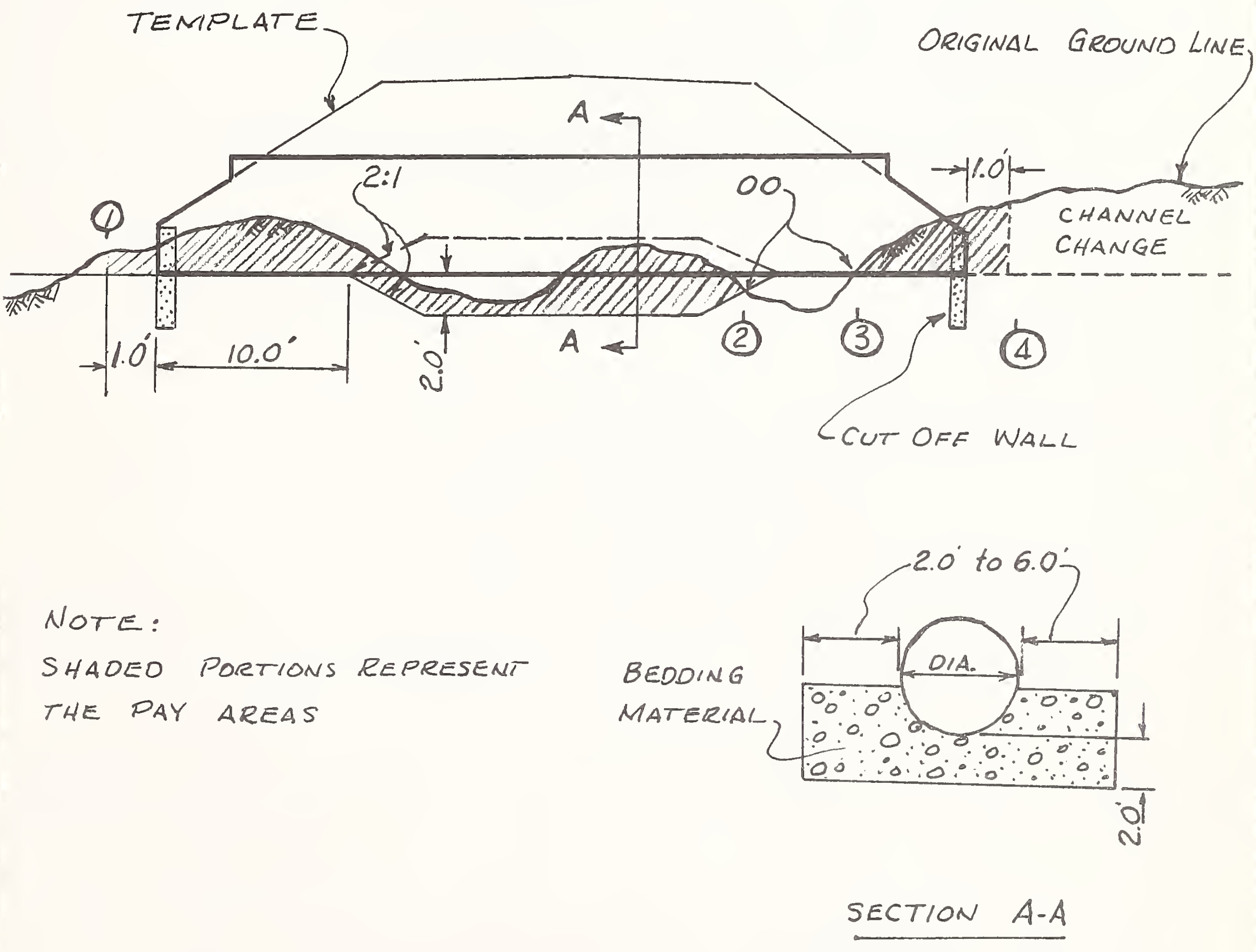
The measurement of the width varies according to the size of pipe and the type of material. Standard Drawing number 54.03 shows the recommended limits. Use 2.0 feet on each side for pipe 60 inches or less in diameter and use from two (2) feet to six (6) feet on larger sizes. The volume will be the cross-sectional area times the width.

The cut-off walls are ignored for culvert excavation because the specifications say the cost of excavating is included in the price bid for the cut-off wall quantities. Also notice the outside diameter is not included for payment on metal pipe. Use the inside diameter instead and ignore the depth of the corrugations.

Assume the following information will apply to Figure 4 in computing the volume.

60 in. x 50 ft. S.S.P.P. Culvert (Steel Structural Plate Pipe)
A = cross-section end area = 100 square feet
W = width = diameter + 3.0 ft. on each side = 5.0 ft. + 6.0 ft. = 11.0 ft.

$$V = A \times W = \frac{100 \text{ sq. ft.} \times 11.0 \text{ ft.}}{27 \frac{\text{cu. ft.}}{\text{cu. yd}}} = 40.7 \text{ cu. yards}$$



NOTE:
SHADED PORTIONS REPRESENT
THE PAY AREAS

REASONABLY STABLE FOUNDATION

BEDDING MATERIAL NEEDED

FIGURE 4

Example For Figure 5

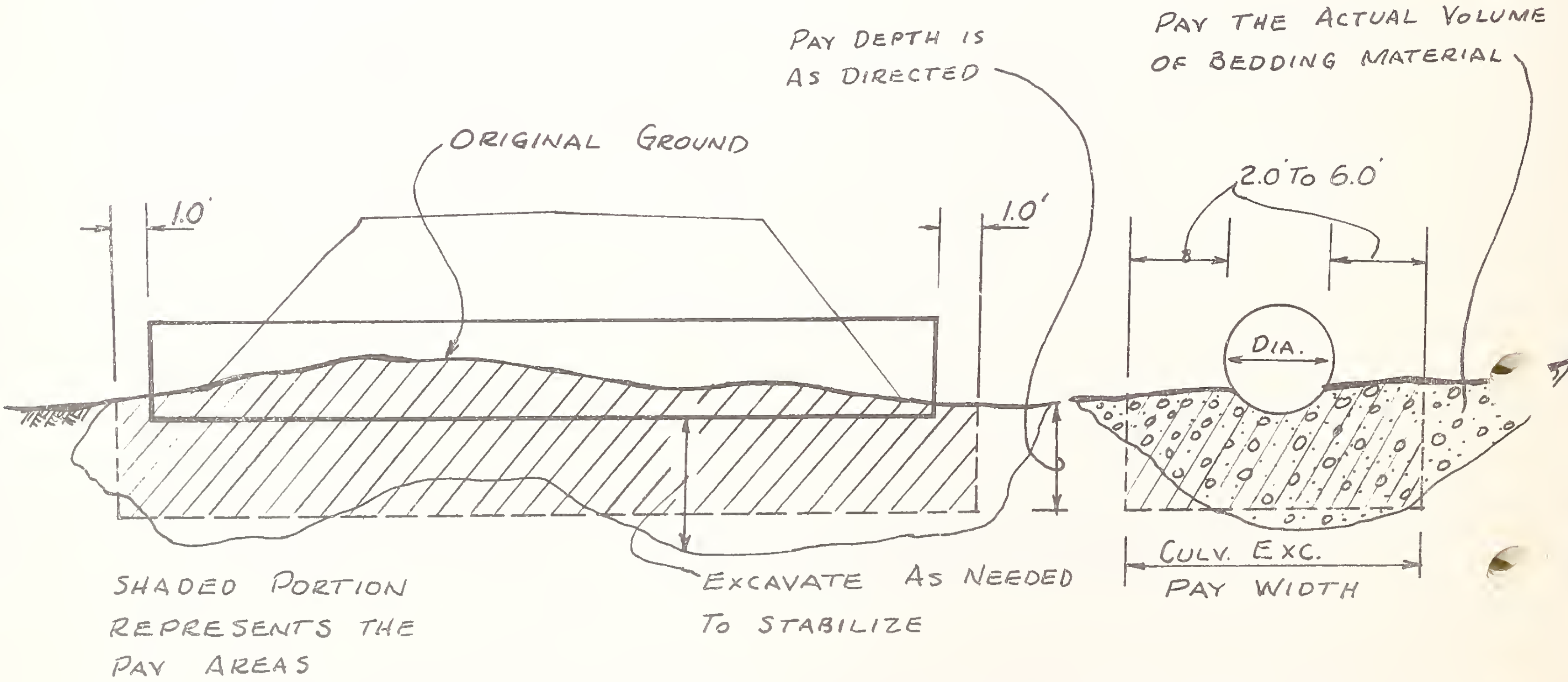
Figure 5 represents a pipe in unstable material. Ordinarily, if the material is not too unstable, the staked dimensions of the bedding material can be used for the culvert excavation measurements. However, some locations are so unstable that the material caves in almost as fast as the dragline removes it and the limits of excavation needed to stablilize the foundation are well beyond the maximum pay width. Such locations will usually qualify for a pay width of six (6) feet on each side of the pipe which is the maximum allowed by specifications.

The contractor of course, will be expected to use pumps and equipment suitable to work unstable locations. The inspector should discuss the pay width with the contractor during the excavation so that if there is any disagreement it can be resolved while everyone can examine the problem.

Assume that the location for a 48 in. x 50 ft. C.S.P. is completely unstable. Compute the volume with the following information shown for Figure 5.

48 in. x 50 ft. C.S.P.
A = cross-section end area = 200 square feet
W = width = diameter + 6.0 ft. on each side = 16 feet

$$V = A \times W = \frac{200 \text{ sq. ft.} \times 16.0 \text{ ft.}}{27 \; \frac{\text{cu. ft.}}{\text{cu. yd.}}} = 118.5 \text{ cu. yds.}$$


PAY DEPTH IS AS DIRECTED
PAY THE ACTUAL VOLUME OF BEDDING MATERIAL
ORIGINAL GROUND
1.0'
1.0'
2.0' TO 6.0'
DIA.
CULV. EXC. PAY WIDTH
SHADED PORTION REPRESENTS THE PAY AREAS
EXCAVATE AS NEEDED TO STABILIZE

UNSTABLE FOUNDATION – BEDDING MATERIAL NEEDED FULL LENGTH

FIGURE 5

B. Bedding Material

Measurement for payment of bedding material is established and recorded in the culvert book when the trench is excavated. The yardage can be computed easily, from the charts shown if the bedding material is placed according to Standard Drawing No. 54-03. Page No. 55-13 of this manual has Standard Drawing No. 54-03 with an example at the bottom of the sheet showing how the tables were developed.

Culverts shown on the Standard Drawings

For an illustration in use of the tables lets assume a 96 inch x 184 foot S.S.P.P.C. is to be installed according to Standard Drawing No. 54-03, and it needs bedding material. Find the volume of bedding material required.

L = length of culvert - earth seal on each end
L = 184 ft. - 2x 12 ft. (earth seal of 10 ft. + ½ of 4 ft. of 2:1) = 160 ft.
Cubic yards of bedding material per linear foot = 1.41 (From Std. Dwg. No. 54-03, 96 inch diameter)

$$V = 1.41\ \frac{\text{Cu. yds.}}{\text{ft.}} \times 160\ \text{ft.} = 225.6\ \text{cu. yds.}$$

Culverts not shown on Standard Drawings

The same general method of computing the cubic yards of bedding material can be used for culverts not shown on Standard Drawing No. 54-03.

For example: Find the volume of bedding material for a 48 inch x 200 foot R.C.P. installed with 4.0 feet of bedding on each side of the pipe and 4.0 feet below the culvert. The installation is in a poor location that required bedding the pipe the full length plus 1.0 foot on each end. Use the following relationships.

$$V = \begin{pmatrix}\text{Volume of}\\ \text{Bedding Material}\end{pmatrix} = \text{width} \times \text{height} \times \text{length} - \begin{pmatrix}\text{Volume Occupied}\\ \text{by the culvert}\end{pmatrix}$$

Mathematically the area of circular segment approximates 5% of the are of the culvert when the pipe bed is shaped to 1/10 the diameter of the pipe as required in Class "C" bedding.

Area of Circular Segment

$A = 5\% \times \pi r^2$ $R = \frac{1}{2} \times 4.8$ (From Std. Dwg. No. 62-01) $\pi = 3.14$

$A = 0.05 \times 3.14 \times 2.4^2 = 0.9$ square feet.

Trench Width

4.8 ft. + 4.0 ft. + 4.0 ft. = 12.8 ft.

Trench Height

1/10 diameter + thickness of bed = 1/10 x 4.8 + 4.0 ft. = 4.5 ft.

Trench Length

200 ft. + 1.0 ft. + 1.0 ft. = 202 ft.

Volume of Bedding Material

(12.8 x 4.5 x 202 - 0.9 x 202) ÷ 27 = 424.2 cu. yds.

Volumes from Hauling Units

We prefer basing the measurement of bedding material on the dimensions of the trench whenever possible. However, there are times when the only way to get a reasonable measurement is from scraper or truck loads. An example is a pipe in a swamp or bog where unstable material makes it impossible to dig a trench that can be measured.

Payment is based on the capacity of the hauling units in cubic yards, adjusted for 30% compaction. For example if 50 - 10 cubic yard truck loads of bedding material are hauled to a culvert bed, the pay quantity is 500 ÷ 1.3 or 387 cubic yards.

Measurement of the hauling units for width, length and height can be recorded in the diary or the gravel notebook. The number of loads can be punched on gravel tickets.

REVISED	1-1-68	11-20-68	7-15-69	STANDARD DRAWING NO. 54-03
EFFECTIVE	2-1-68	1-1-69	1-1-70	

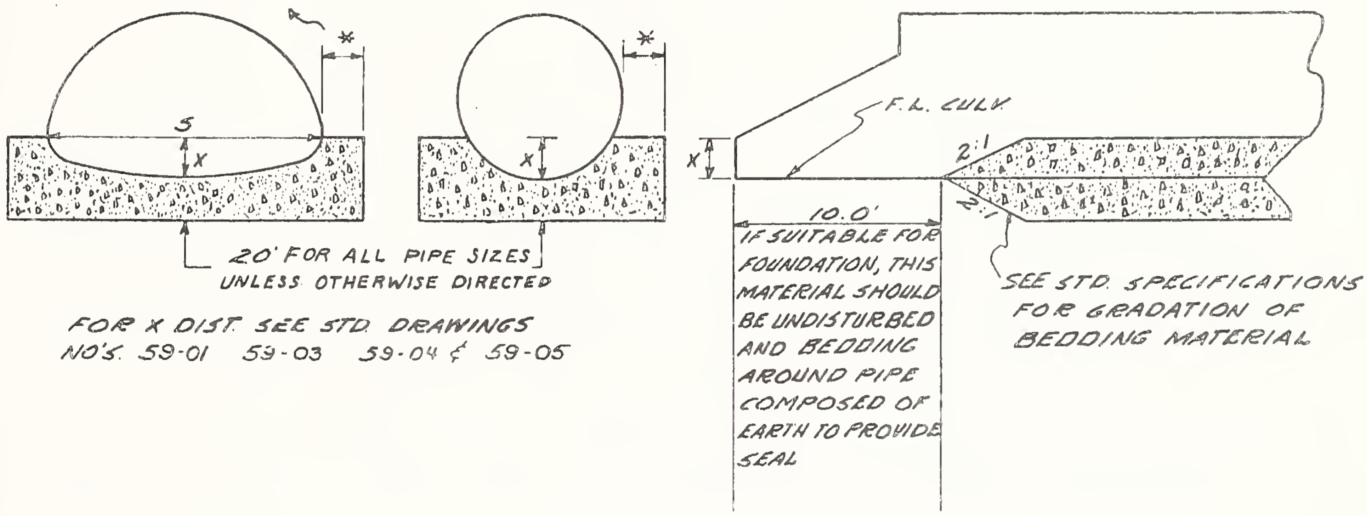
State Highway Commission
Helena, Montana

BEDDING MATERIAL

Approved
State Highway Engineer

*AS DIRECTED WITHIN 2.0' TO 6.0' FOR PIPES GREATER THAN 60" DIAMETER OR SPAN, AND 2.0' FOR SMALLER PIPES ON STABLE FOUNDATIONS

THE WIDTH AND LENGTH OF BEDDING MATERIAL WILL BE AS DIRECTED FOR ANY SIZE PIPE PLACED ON STABLE FOUNDATIONS.



2.0' FOR ALL PIPE SIZES UNLESS OTHERWISE DIRECTED

IF SUITABLE FOR FOUNDATION, THIS MATERIAL SHOULD BE UNDISTURBED AND BEDDING AROUND PIPE COMPOSED OF EARTH TO PROVIDE SEAL

SEE STD. SPECIFICATIONS FOR GRADATION OF BEDDING MATERIAL

FOR X DIST. SEE STD. DRAWINGS NO'S. 59-01 59-03 59-04 & 59-05

CIRCULAR C.S.P. & S.S.P.P.C.

DIAMETER OF PIPE (IN.)	CU. YDS. BEDDING MAT'L. REQ'D. PER LIN. FT. FOR 2.0' THICKNESS	DIAMETER OF PIPE (IN.)	CU. YDS. BEDDING MAT'L. REQ'D. PER LIN. FT. FOR 2.0' THICKNESS
60	[illegible]	162	2.45
			2.54
90	1.23	198	3.10
96	1.41	204	3.22

STRUCTURAL PLATE PIPE ARCH

SPAN	RISE	CU. YDS. BEDDING MAT'L. REQ'D PER LIN. FT. FOR 2.0' THICKNESS		
		1½:1 BEV.	2:1 BEV.	2½:1 BEV.
18" CORNER PLATES				
	6'7"		1.16	1.16
	5'7"	[illegible]		
8'7"	5'11"	1.37	1.37	[illegible]
9'6"	6'3"	1.27	1.47	1.47
16'6"	11'0"	2.36	2.36	2.36
17'11"	11'8"	2.58	2.58	2.58
19'3"	12'4"	2.77	2.77	2.77
20'5"	13'0"	2.91	2.91	2.91

STRUCT. PLATE PIPE ARCH STOCK & UNDERPASS

STRUCT. PLATE PIPE STOCKP

SPAN	RISE	CU. YDS. BED REQ'D

Find Volume Bedding Material per linear foot
Use a 96" S.S.P.P.C. for an example

X = 2.0 ft. (Std. Dwg. 59-03); Area Circ. Segment "A" = 9.81 sq. ft.
Width = 8+2+2 = 12.0 ft.; Height = X + thickness = 2+2 = 4 ft.
V = Volume = Width x Length x Height - Volume occupied by culv.

$$\underline{V} = (1\times12\times4 - 9.81\times1) \div 27 \frac{\text{cu. ft.}}{\text{cu. yd.}} = \frac{48.98}{27} = 1.41 \text{ cu. yd. per ft.}$$

INSPECTION & INSTALLATION OF CULVERTS

56.00 References

Standard Specifications: Section 52 through 69
and Section 74

Standard Drawings

Construction Manual: III - 32, and IV - 55 thru IV - 62

56.01 General

Highway drainage is associated with the removal and control of water movement along or under the highway. The water involved may be from surface run-off, natural stream flow either above or underground, irrigation, sewage or a high water table. The proper collection and disposal of water, to prevent damage to the highway and adjacent or downstream landowners, is essential to successful construction. Failure to adequately provide drainage solutions is either directly or a contributing cause of most highway failure.

Drainage systems are developed during location and planning with decisions based on information available at that time, however, it is difficult to anticipate all drainage problems that may result from construction of the highway, particularly with respect to underground water. Correction of deficiencies shown on the plans is the direct responsibility of project personnel. If all design problems are solved regarding drainage, poor installation practices can still cause failure of the roadway; therefore, the other responsibility of project personnel is to inspect construction procedure. It is evident that drainage inspection should be entrusted to competent experienced personnel who are capable of recognizing drainage problems and understanding proper construction methods.

56.02 Revised Culvert List

The revised culvert list is prepared by the Project Manager for the contractor to use in ordering culverts. The list, ideally, should be prepared from staked culvert dimensions but sometimes plan dimensions will have to be used if the culverts must be ordered before all the pipes are staked. However, in all cases, the list should be made up from the latest and best information available. Normally, it is not possible to prepare a complete list of all installations the first time, so as the work progresses additional lists will have to be furnished the contractor.

When preparing the culvert list for the contractor care should be taken that the length given can be fabricated. Regular pipe sections are manufactured in even foot lengths, multiple lengths of 2' for RCP, so installations will always be ordered in even feet. Flared end terminal section (F.E.T.S.) dimensions can be found in the Standard Drawings. The manufacturer will sometimes have to donate a few inches, and sometimes the State will, but it should balance out for the total pipe on the project.

56.03 Staking Inspection

The drainage inspector should check the culvert staking for slope, length, and flow line.

First check the special provisions, R/W agreements, plans and summary sheets for special instructions that could affect the grade, flow line or length of the culvert. Irrigation culverts, in particular, usually have some special restrictions or provisions.

A. Flow Line

Flow line is the elevation of the inside bottom of the culvert; therefore, shell thickness in rigid pipe must be considered when establishing flow line elevations. Flow line elevations of the culvert should match outlet elevations of the channel, stream bed, irrigation ditch or channel change, but may be 0.1' - 0.3' below channel grade at the inlet. This can be easily checked with a hand level. Hubs and guard stakes, offset from the culvert ends, will be marked either cut or fill in relation to the flow line elevation, or culvert bed elevation. The stakes should always show which elevation the cut or fill is referring to. See Sketch in Figure Number 56-1 below.

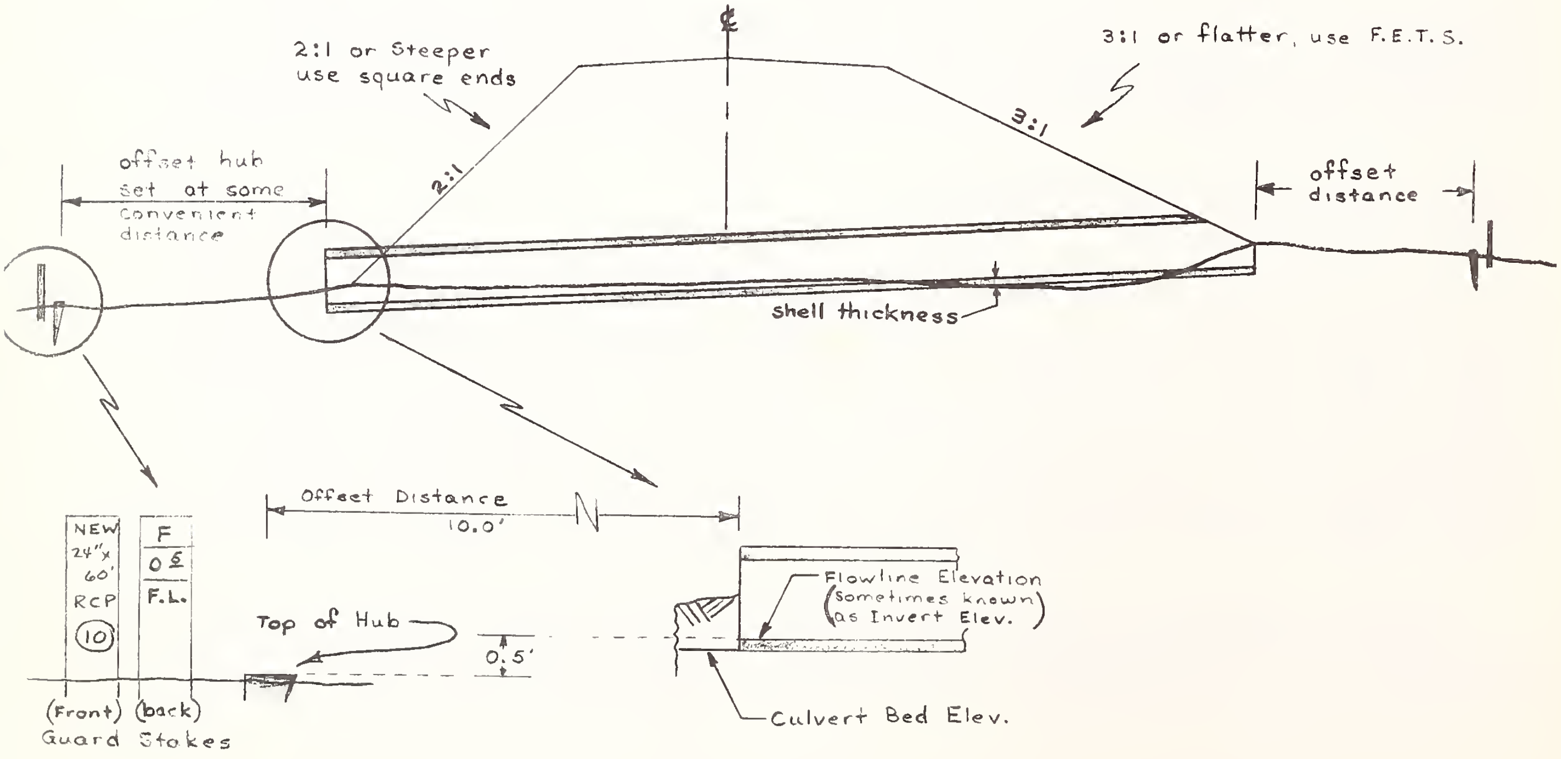

℄
2:1 or Steeper use square ends
3:1 or flatter, use F.E.T.S.
3:1
2:1
offset hub set at some convenient distance
offset distance
shell thickness
Offset Distance
10.0'
NEW 24"x 60' RCP
10
F
0 ℄
F.L.
Top of Hub
0.5'
Flowline Elevation (Sometimes known as Invert Elev.)
Culvert Bed Elev.
(Front) (back)
Guard Stakes

FIGURE 56-1

B. Slope

Slope of the culvert is the ratio of the drop to the length. For example, if a 200 ft. long culvert has an inlet flow line elevation of 3862.0 and an outlet flow line elevation 3860.0, the drop would be 2.0 ft. in 200 ft. or 1 ft. per 100 ft. One percent drop, one percent grade or one percent slope would all be the same slope expressed in different terms. Ordinarily the most desirable slope is the slope of the channel that the culvert replaces; however, in many cases this is not possible or practical because construction of the highway causes the channel length, flow line or both to change.

To understand the problems that can develop at different slopes, the inspector should be aware of the meaning of critical slope in a culvert. Critical slope is the slope at which maximum discharge is achieved with the water surface at the top of the culvert at the inlet end. Increasing the slope beyond the critical slope does not increase the discharge but does increase the velocity of the discharge. Slopes in the range from one to two percent for CMP and from one-half to one percent for RCP are equal or greater than the critical slope and are usually sufficient to avoid silting, yet velocities are not great enough to cause excessive scour.

Slopes below 0.3 percent for concrete culvert and 0.5 percent for CMP will silt badly and every effort to increase the slope above this minimum should be explored to avoid future maintenance costs. In some cases it will be advisable to stake the inlet high and allow some ponding until natural silting adjusts the flow line to the new inlet elevation. See Figure 56-2 below:

Raising inlet end to increase the slope and prevent silting in the culvert.

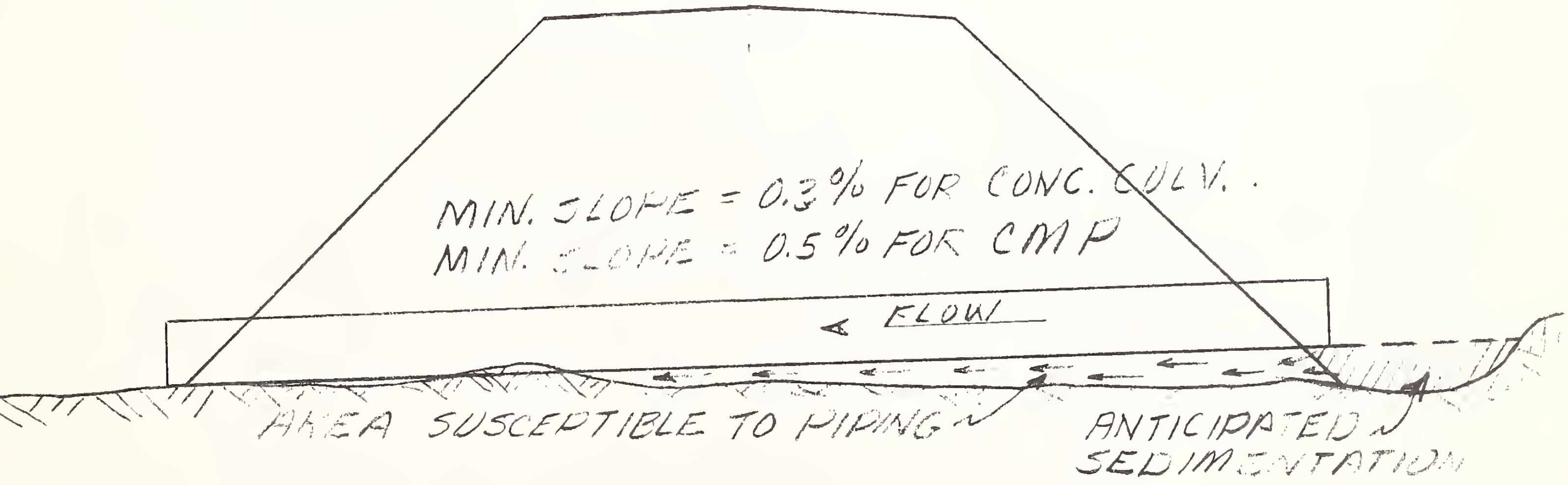

MIN. SLOPE = 0.3% FOR CONC. CULV.
MIN. SLOPE = 0.5% FOR CMP
FLOW
AREA SUSCEPTIBLE TO PIPING
ANTICIPATED SEDIMENTATION

FIGURE 56-2

This type of installation should only be attempted in areas with reasonably impervious soils where piping is unlikely (piping is an internal erosion of the soil causing a channel to be formed alongside or under the culvert).

In general culverts placed in cut sections, where an outlet ditch cannot be constructed, should be avoided. The roadway ditch elevations right and left of centerline are equal on a tangent section; therefore, to avoid silting in the pipe the roadway ditch receiving the water may have to be lowered and widened to provide slope, this in turn requires more R/W which often is not available. If the roadway grade is relatively flat it is difficult to drain the roadway ditch; a steep roadway grade causes increased ditch erosion because of the increased amount of water. Despite the disadvantages it sometimes is necessary to install a culvert in a cut see Figure 56-3 below:

Lowering outlet end to increase the slope and prevent silting in the culvert.

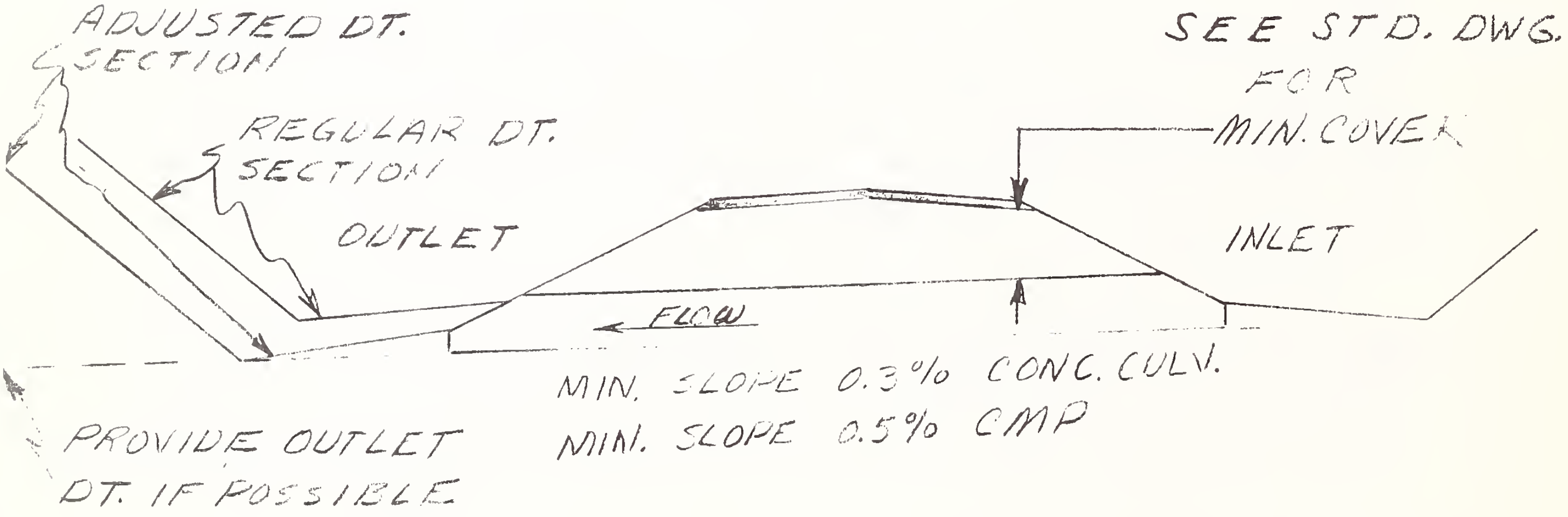
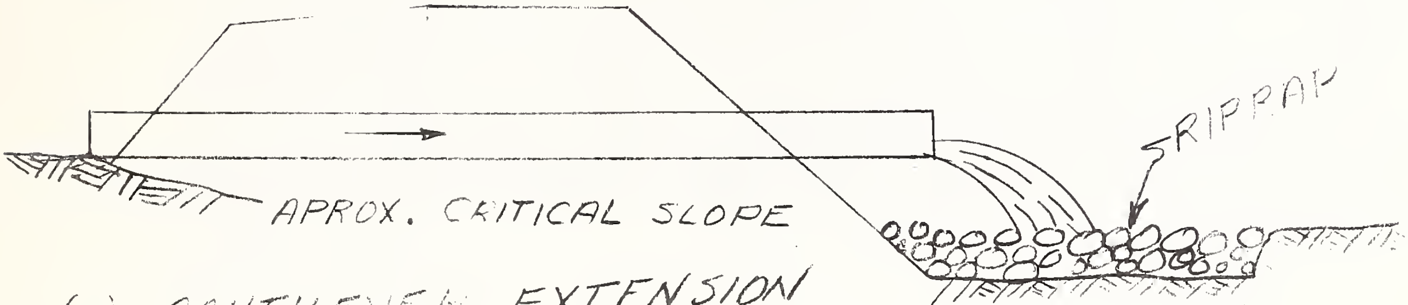


FIGURE 56-3

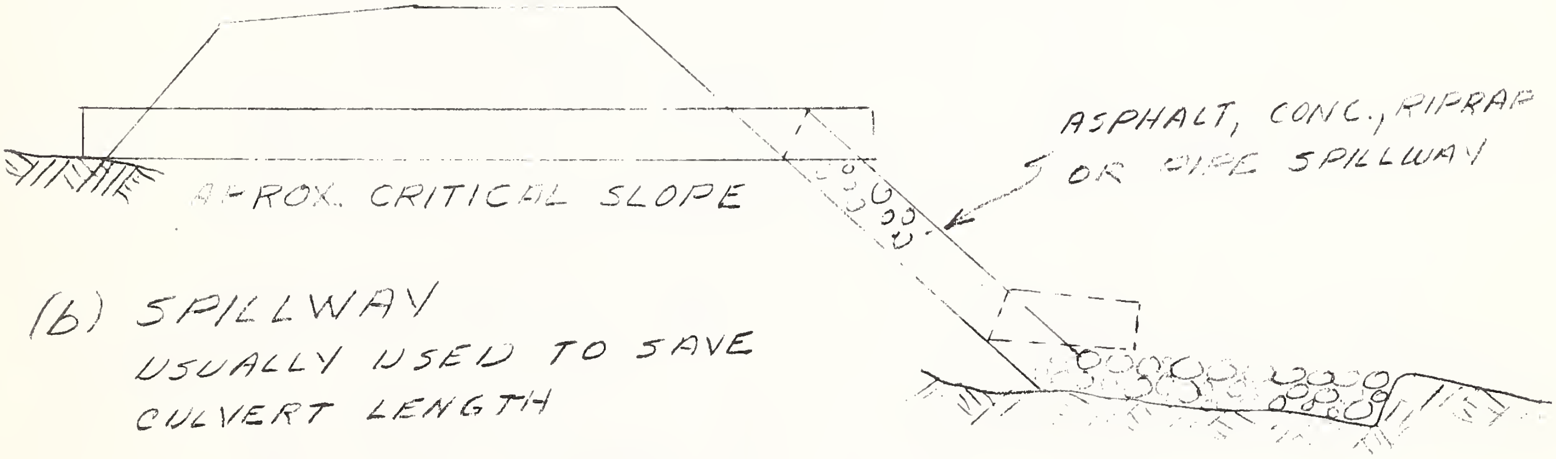
Slopes of two percent or greater may have erosive velocities, especially at the culvert outlet; although, the percent of slope that will cause erosion varies in different soil. For example, a two percent slope might be erosive for a silty soil but up to 6 percent might not be excessive for a coarse gravel. Various methods have been used successfully to reduce velocity and prevent erosion, including riprap, head walls, concrete or asphalt aprons, energy dissipators, etc. The drainage inspectors' responsibility is to alert the Project Manager that a potentially erosive slope exists and discuss with him the form of correction that is needed. See Sketches in Figure 56-4:

CONSTRUCTION DETAILS

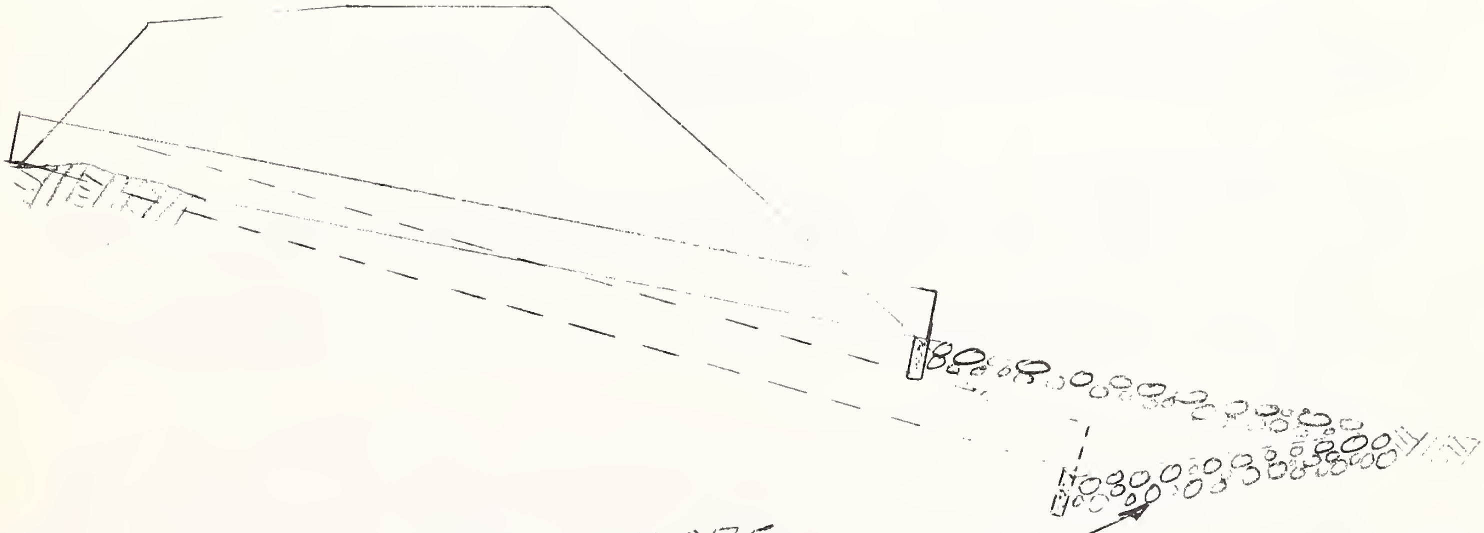
Examples of culvert installations where the difference in elevation between the inlet and outlet is large.



(a) CANTILEVER EXTENSION
SHOULD NOT BE USED WHERE DROP IS VERY LARGE



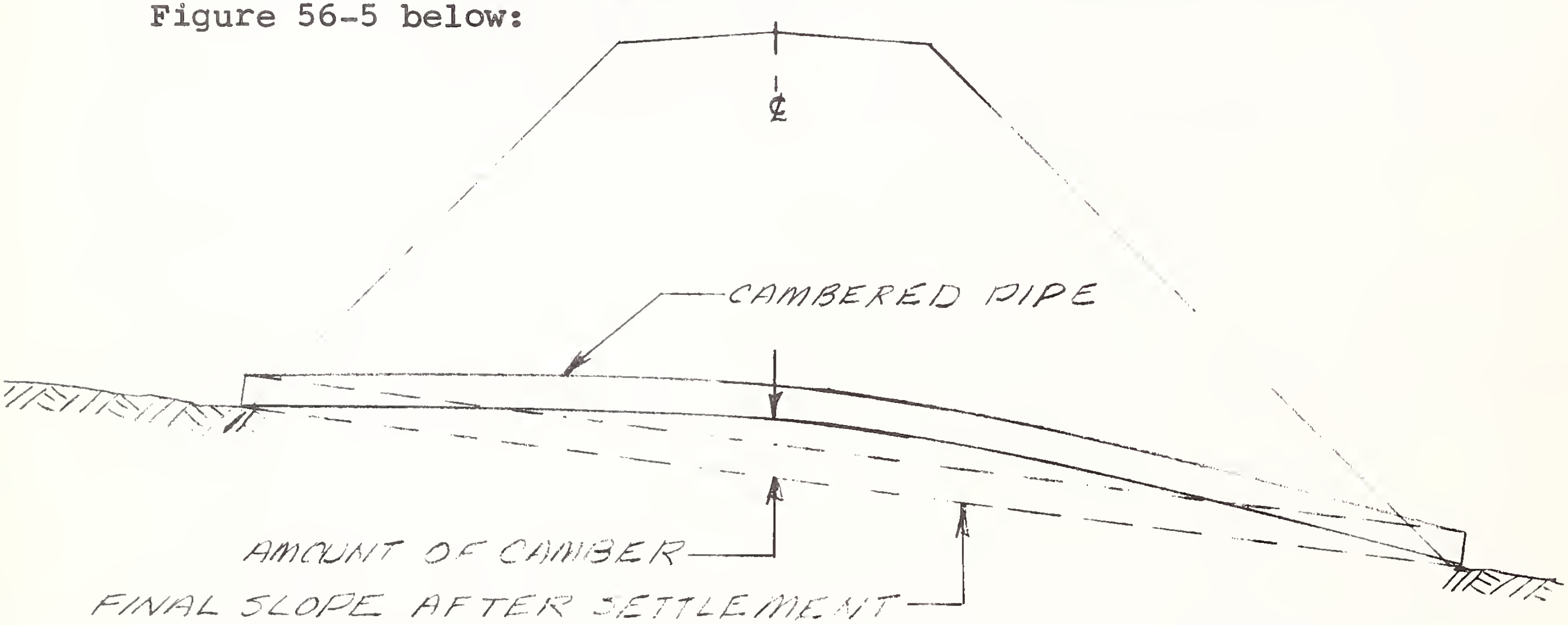
(b) SPILLWAY
USUALLY USED TO SAVE CULVERT LENGTH



(C) PIPE ON STEEP SLOPE
MOST COMMON INSTALLATION

FIGURE 56-4

"Camber" (adjusting the slope, usually in the center of the culvert to compensate for anticipated pipe settlement) is frequently required under high fills. The amount of camber used varies, depending on the type of soil and height of fill; but the choice is largely a matter of experience and judgment. Some engineers use ½ of 1 percent of the total length, others lay the upstream end level and increase the downstream slope. Be careful not to raise the center of the pipe above inlet elevation because water will pocket if the anticipated settlement does not occur. See Figure 56-5 below:



FLOWLINE OF CAMBERED PIPE CAN BE STAKED AS A VERTICAL CURVE, OR BY THE RATIO OF CAMBER TO LENGTH.

FIGURE 56-5

Approach pipe flow line and slope equal the elevation and slope of the roadway ditch in a cut section. The roadway section will ordinarily be cut to grade before these installations are made.

Extreme caution should be used in changing the grade of culverts in irrigation ditches, the irrigation culvert flow lines and slope should match the irrigation ditch that the culvert replaces. Irrigation ditch grades are very critical and before any adjustments are made, permission and approval must be attained from the landowner and from the irrigation district or government agency controlling the ditch.

When extension of culverts in place is necessary, it sometimes is very difficult to match the slope of the culvert in place. If the slope difference is sufficient to cause silting or erosion damage, the culvert in place should be removed and relaid.

C. Length

The culvert length depends upon roadway width, height of fill, side slopes, grade, alignment and whether flared end terminal sections or square ends are used.

A sketch of a typical installation (Figure 56-6) and a sample computation sheet for determining the length follows.

COMPUTATIONS:

From Figure No. 56-6

Lt. Side Length
Lt. Shld. Subgrade Elev. = 4020.0
Lt. Flow Line Elev. = -4005.0
Height of Fill = 15.0'
Rate of Slope 3:1 = X3
Horz. Dist. to Slope Stake = 45.0'
Subgrade Width = +25.0'
Dist. From Stake to End F.E.T.S. = -4.0' See Figure 56-6 (a)
Lt. Side Pipe Length = 66.0' = B + 1/2 A

Rt. Side Length
Rt. Shld. Subgrade Elev. = 4020.0
Rt. Flow Line Elev. = -4004.0
Height of Fill = 16.0'
Rate of Slope 2:1 = X2
Horz. Dist. to Slope Stake = 32.0'
Allowance for Slough = +2.0'
Subgrade Width = +25.0'
Rt. Side Pipe Length = 59.0' = 1/2 A + C

(Pipe Sections are Fabricated in even Feet; therefore, the Total Length must be even -- It is customary to Round Up).

TOTAL LENGTH OF INSTALLATION PERPENDICULAR TO CENTERLINE OF ROADWAY:

Lt. Side Pipe Length = 66.0' = B + 1/2 A
Rt. Side (Round to Even Ft.) = 60.0' = C + 1/2 A
Total Length of Pipe = 126.0' = A + B + C

LENGTH OF THE ABOVE INSTALLATION IF IT WERE SKEWED AS IN FIGURE 56-6 (c) ASSUME 14° skew:

Lt. Side = (1/2 A + B) ÷ Cos. 14° = 66.0 ÷ 0.97030 = 68'
Rt. Side = (1/2 A + C) ÷ Cos. 14° = 59.0 ÷ 0.97030 = 62' (60.8' Rounded)
Total Length of Pipe =130.'

Notice in Figure 56-6 (a) that if this pipe was installed on a 5:1 slope the F.E.T.S. would not fit as well, and would require subtracting 8 ft. ± instead of 4 ft. to fit the slope. Don't get too technical in adjusting lengths for F.E.T.S. but be aware that the dimensions of F.E.T.S. does influence pipe length.

An additional computation adjusting the culvert length for long culverts on steep slopes is sometimes required; especially on Interstate projects, because the four-lane section is so wide. A sample computation using assumed measurements different from those in Figure 56-6 (b), but using letter designation the same as shown on the drawing, is listed below:

ASSUME: Diff. in Elev. Inlet to Outlet = $h = 60.0'$
Horizontal Distance $= A+B+C = 300.0'$

Length of pipe needed for slope $= \sqrt{(A+B+C)^2+h^2} = \sqrt{600^2 + 60^2} = 306'$

OR:

$$\text{Slope} = \frac{h}{A+B+C} = \frac{60}{300} = 0.20000 = \text{TAN } X, \text{ from tables}$$

$$\text{Angle } X = 11^\circ\ 19'\pm\ ;\ \text{Pipe Length} = \frac{A+B+C}{\text{COS. } X} = \frac{300}{\text{COS. } 11^\circ 19'} = 306'$$

In this case the slope has increased the pipe length from 300 feet to 306 feet.

EXAMPLE SHOWING TYPICAL INSTALLATION AND METHOD OF DETERMINING CULVERT LENGTH

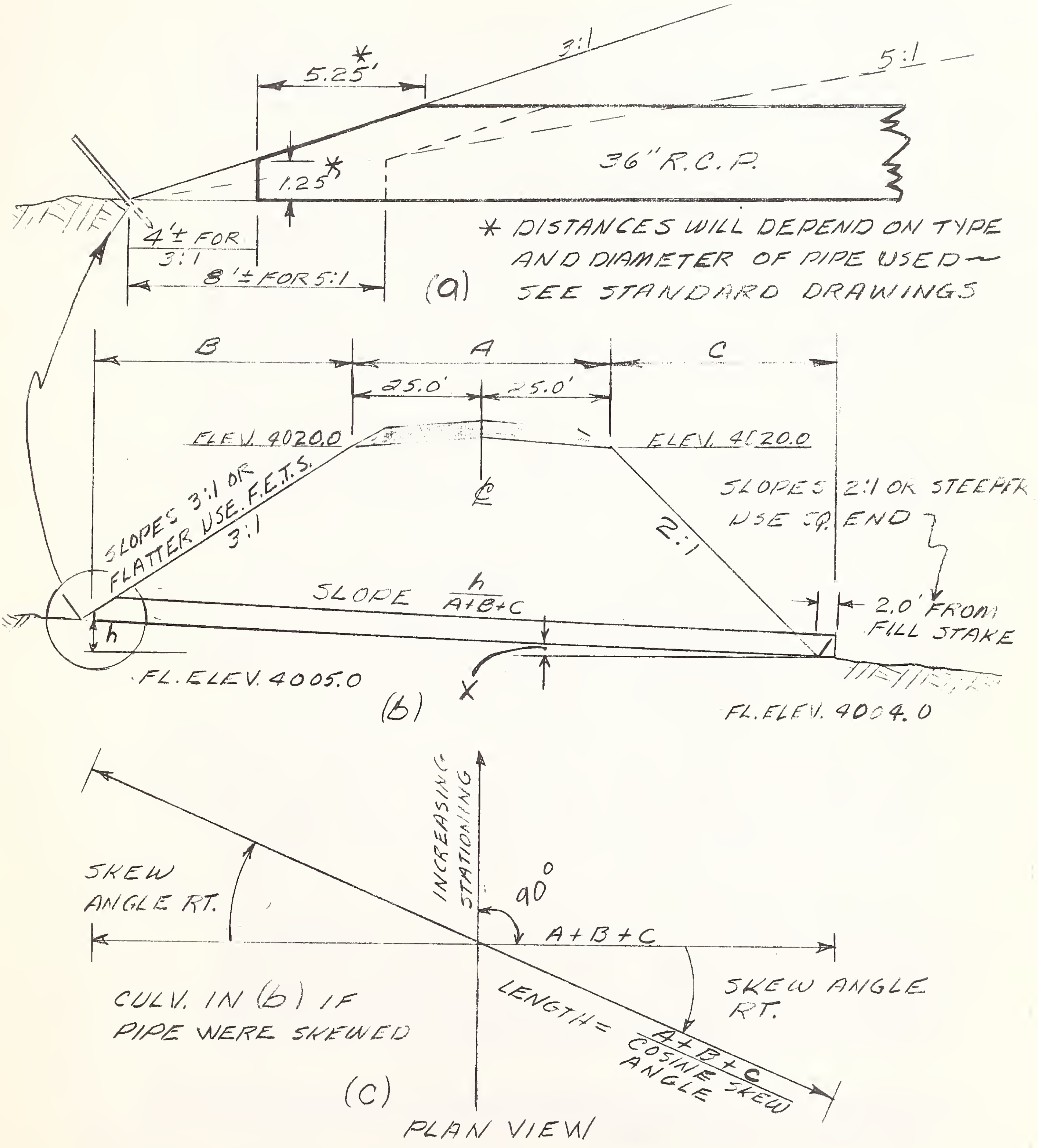


FIGURE 56-6

56.04 Backfilling and Compaction

An excellent pipe installation up to the point of placing backfill material can be ruined by allowing poor construction procedures in placing the backfill. No backfilling should ever be permitted without a State inspector present.

The inspector will be expected to direct the taking of compaction tests; specifications require that the backfill be compacted to a uniform density and meet the standard density requirements for embankment. Compaction tests are a valuable aid in determining whether compaction in general is satisfactory; however, there is a limit to the number of tests that can be taken, the efforts of the inspector are still the most reliable insurance that proper compaction is being obtained. Chances for a good installation will be increased if the inspector will observe and enforce the following rules in construction procedures:

(a) Select the best material available for backfill, avoid topsoil, stones and frozen soil. Some porous materials allow water movement through the particles and consideration should be given to providing a seal of more impervious material around the pipe.

(b) Compact the backfill under the pipe haunches (lower ¼ of culvert) on both sides to obtain all the bearing possible. This can only be accomplished by hand tamping, its effectiveness can be checked by trying to poke a stake under the culvert. Failure to properly tamp under the haunches causes lateral movement, excessive stress on the lower ¼ of the culvert and water movement along side rather than through the culvert.

The contractor may complain that tamping under the haunches will force the pipe up or out of line. This is possible and must be avoided, but many times this is just an excuse for not wanting to put in the necessary hand labor.

(c) Insist on well mixed moisture within the + or - two percent of optimum moisture requirement. Backfill soils are much easier to compact to required densities at optimum moisture, therefore, there is less chance of causing distortion or movement of the pipe during placing and compaction of backfill. It is unlikely that the proper uniformity of compaction will be obtained unless ±2 percent of optimum moisuture is used.

This specification admittedly is difficult to enforce but to have good culvert installations it is probably the most important to comply with.

(d) Backfill must be brought up uniformly around the culvert in lifts not to exceed 6" loose thickness for the entire length of the culvert. Unequal backfilling can cause the structure to be pushed out of line or subjected to stresses for which it is not designed.

(e) Heavy equipment shall not be allowed to operate over the culvert until the pipe has been covered to a depth of 1/2 the pipe diameter but in no case less than 4 feet of compacted material. Loaded heavy equipment usually far exceeds design loading and many pipe failures are caused by permitting premature hauling over the culvert.

Failures are especially likely to occur on pipe that the contractor places temporary cover over to permit hauling. In these cases, the inspector should be sure that the pipe is ramped over on a gradual slope rather than as a large bump. The impact of a loaded high speed scraper hitting one of these bumps is tremendous.

If hauling units are making repeated trips over a culvert, be certain that they utilize the full width of the roadway and do not develop a narrow haul path. Any damage caused to culverts by the contractor's hauling units will be the contractor's responsibility to repair or replace.

(f) Culverts that are to be placed under an embankment principally composed of blasted or fractured rock require special care to prevent puncture or breaking of the culvert. The method of placing the material is explained in the Standard Specifications under Backfilling-Rock Embankment.

(g) Very high fills sometimes require backfilling by the imperfect trench method. The principal reason for imperfect trench construction is to reduce the weight on the culvert by transfer of pressure from a yielding mass of soil onto an adjoining relatively rigid soil. Construction procedures to accomplish this are fully described in the Standard Drawings under Class B-1 and C-1 bedding.

The imperfect trench method will not be used unless specifically called for on the plans. There may be exceptions to this whereby unusual field conditions warrant consideration of its use; however, before proceeding, approval from the Hydraulics Department and the Federal Highway Administration will be required.

The records, notes, construction procedure, pipe inspection, etc., discussed in the preceding paragraphs apply in general for all small drainage installations. Certain problems unique to underground or sub-surface drainage, remove and relay culverts and sewers will be discussed in more detail.

56.05 Sewers

The inspector should inspect the plans, detail drawings and the special provisions for the type of pipe that is to be used, and for special installation requirements. Ordinarily the type of pipe used by the sewer system in place will be specified; this may be metal, concrete, clay, fiber, plastic, etc.

The usual procedure in establishing the slope is to excavate to the flow line at the beginning and end of the sewer relocation and to any auxillary or side connections that might be affected along the line to be certain that flow line elevations are correct. Minimum grades recommended by the Board of Health for sanitary sewers are listed below:

4"	1.2	feet	per	100	ft.
6"	0.6	"	"	"	"
8"	0.4	"	"	"	"
10"	0.29	"	"	"	"
12"	0.22	"	"	"	"
15"	0.15	"	"	"	"
18"	0.12	"	"	"	"
24"	0.08	"	"	"	"
30"	0.06	"	"	"	"
36"	0.044	"	"	"	"
42"	0.036	"	"	"	"
48"	0.032	"	"	"	"

For storm sewers, the minimum grade should be somewhat steeper than for sanitary sewers.

It is best to have the sewer trench excavated well ahead of the actual pipe laying because encountering unforeseen obstructions in the path is a good possibility. Water, gas, telephone and electrical conduits can be moved above or below the sewer being constructed; however, be certain that no adjustment of these lines is made until you have the owners approval. Backfilling of the trench should follow as near as feasible behind the laying of the sewer pipe to keep the amount of open trench at a minimum. All open trenches should be well barricaded to protect the public. If a sanitary sewer line is in the path it usually cannot be moved and it will be necessary to modify the slope of the new line.

Slopes in sewer lines are very critical because they are designed for a complete system and disturbing one portion will cause trouble to develop in other portions of the system. Any adjustment of slope will require prior approval of the sewer owners. When considering changing slopes remember that flattening the grade may require a larger size culvert and any abrupt changes in slope will require a manhole.

Sewer lines are usually staked by running a line of offset hubs either left or right, where they will not be destroyed, with the cut and offset distance marked on guard stakes. Distance and elevation of flow line can then easily be transferred to batter boards for control of installation.

Water tight joints are important and every precaution to insure this result should be taken. When a section of pipe is set to grade it should be secured with tamped backfill on each side so that it will not be displaced or the previous joint seal broken when the next section is layed.

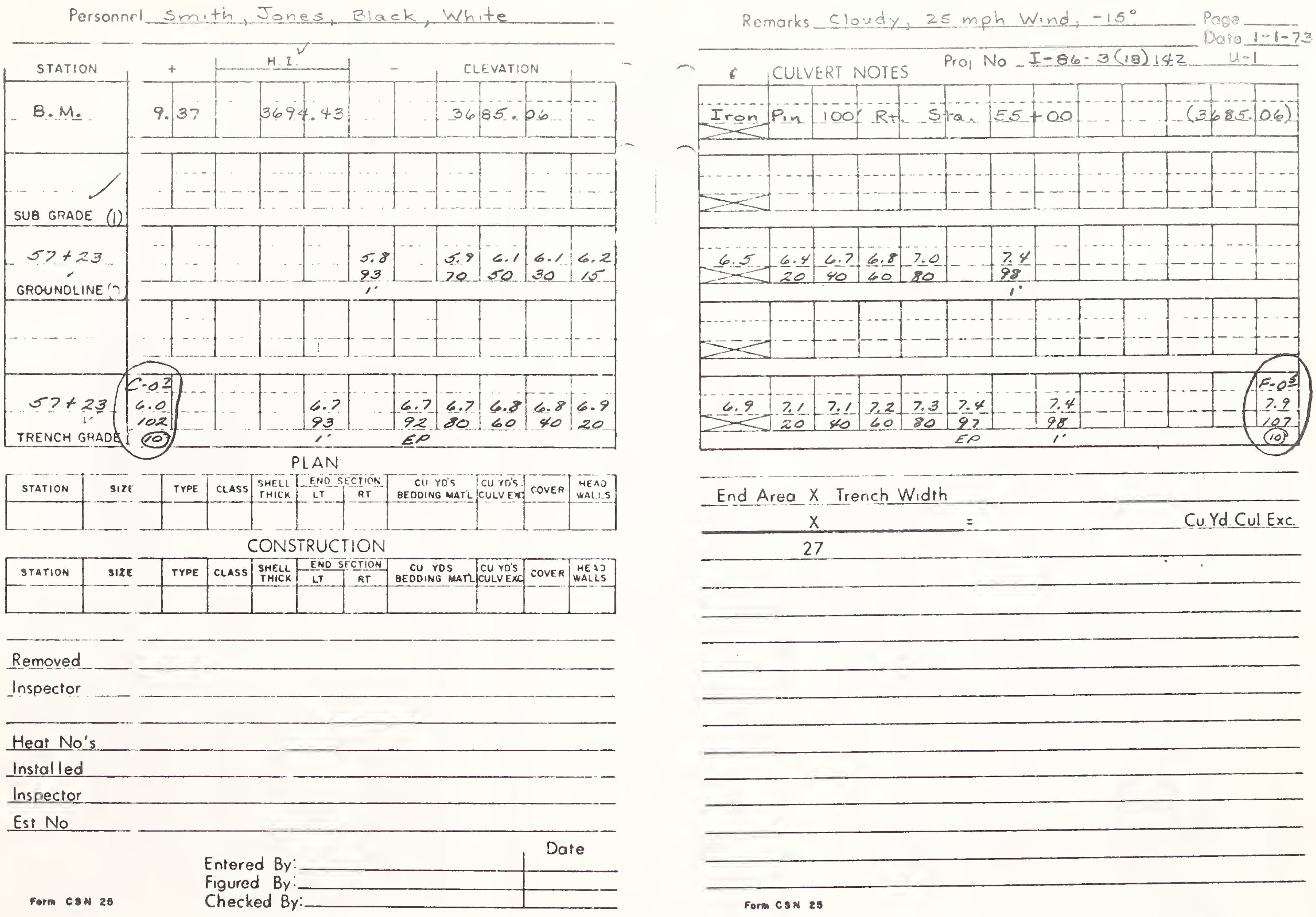
The culvert inspector should have close liaison with the cities or other concerned to insure that they are satisfied with the planned installation. Good records are particularly important because the cities will need accurate flow line elevations and locations and may request copies of the notes.

56.06 Records and Documentation

Culvert notes (Form CSN-25) have been developed which are designed to be a field aid. The note form provides space for all the information normally required for culvert installation plus space for additional comments about the particular installation. Below is listed a set of instructions for the use of the standard culvert note form so that culvert excavation can be calculated by electronic computer.

1. At the top of the page an area has been designated for computation of an H.I. elevation. It is required that an H.I. be given for each culvert.

2. The note form provides a location for sub-grade, groundline, and trench-grade rods and distances. For each culvert installation, the complete trench profile (NOT FLOW LINE PROFILE FOR RIGID PIPE) will be required and the groundline profile. The groundline profile should be the payline that will be used to compute the culvert excavation quantity. The subgrade profile need not be recorded but may be included as a field aid in locating the payline. If the sub-grade profile is shown it should be circled. Shots that are circled will not be key punched for electronic computation of culvert excavation. All offsets, all shots on the sub-grade line, and all shots on any line, that are purely informational, should be circled. Some sample notes are included for guidance on proper recording of the various profiles.



Personnel Smith, Jones, Black, White

STATION	+		H.I.			-		ELEVATION			
B.M.	9.37		3694.43					3685.06			
SUB GRADE (1)											
57+23 GROUNDLINE (?)						5.8 93 1'		5.9 70	6.1 50	6.1 30	6.2 15
57+23 TRENCH GRADE	C-0^{2} 6.0 102 (10)				6.7 93 1'		6.7 92 EP	6.7 80	6.8 60	6.8 40	6.9 20

PLAN

STATION	SIZE	TYPE	CLASS	SHELL THICK	END SECTION LT	END SECTION RT	CU YD'S BEDDING MAT'L	CU YD'S CULV EXC	COVER	HEAD WALLS

CONSTRUCTION

STATION	SIZE	TYPE	CLASS	SHELL THICK	END SECTION LT	END SECTION RT	CU YDS BEDDING MAT'L	CU YD'S CULV EXC	COVER	HEAD WALLS

Removed

Inspector

Heat No's

Installed

Inspector

Est No

Entered By: Date

Figured By:

Checked By:

Form CSN 28

Remarks Cloudy, 25 mph Wind, -15°

Page

Date 1-1-73

Proj No I-86-3(18)142 U-1

℄	CULVERT NOTES											
Iron	Pin	100'	Rt.	Sta.	55+00						(3685.06)	
6.5	6.4 20	6.7 40	6.8 60	7.0 80		7.4 98 1'						
6.9	7.1 20	7.1 40	7.2 60	7.3 80	7.4 97 EP		7.4 98 1'					F-0^{5} 7.9 107 (10)

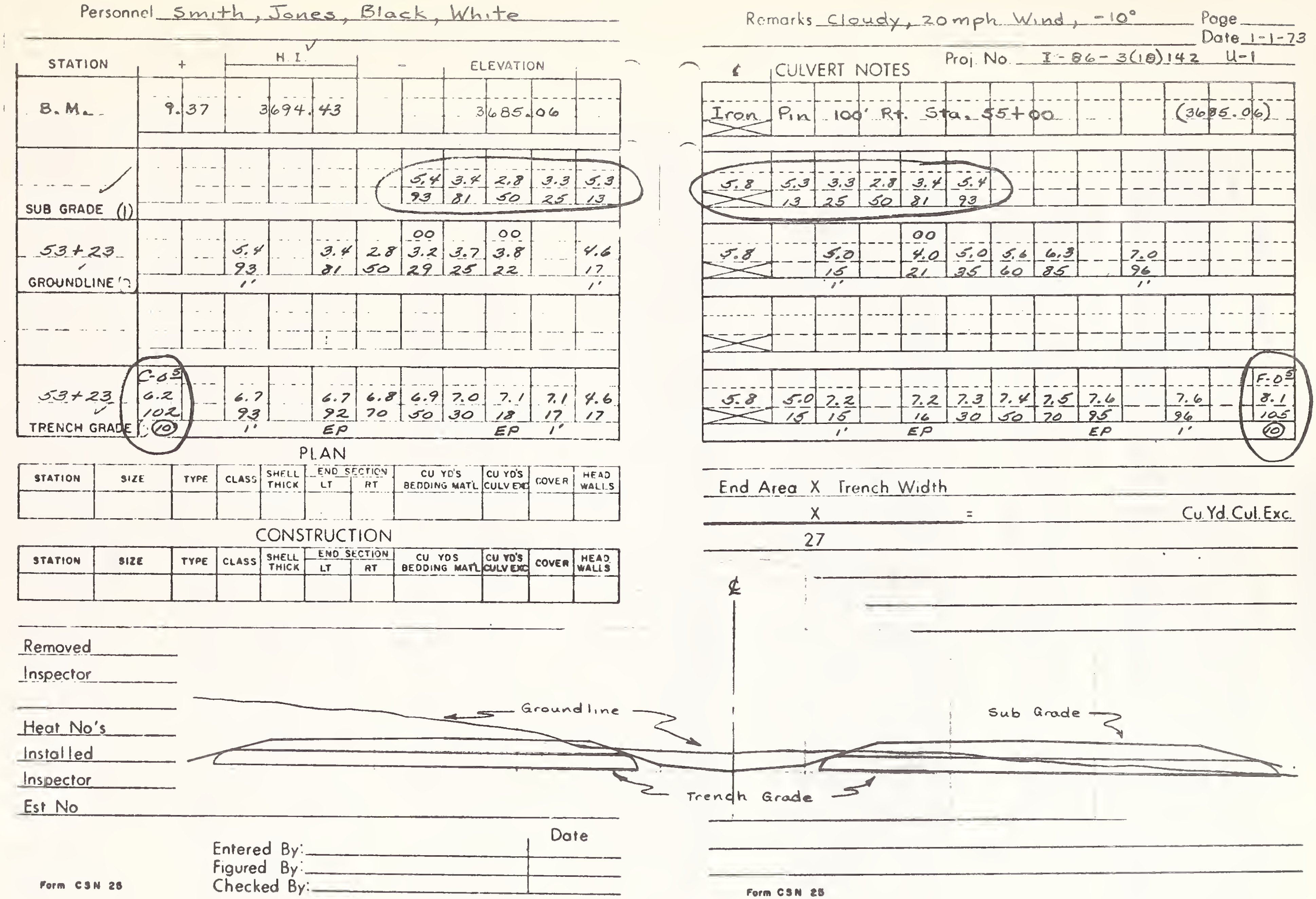
End Area X Trench Width

X = Cu Yd Cul Exc.

27

Form CSN 25

Fig. 56-7: Fill Section. Sub-grade profile may be included but is not necessary. Groundline and trench grade both must have a shot 1' beyond the end-of-pipe distance to compute culvert excavation.



Personnel Smith, Jones, Black, White

Remarks Cloudy, 20mph Wind, -10°

Page

Date 1-1-73

Proj. No. I-86-3(18)142 U-1

STATION	+		H.I.			-		ELEVATION			
B.M.	9.	37	3694.		43			3685.	06		
SUB GRADE (1)							5.4 93	3.4 81	2.8 50	3.3 25	5.3 13
53+23 GROUNDLINE (2)			5.4 93 1'		3.4 81	2.8 50	00 3.2 29	3.7 25	00 3.8 22		4.6 17 1'
53+23 TRENCH GRADE	C-0.5 6.2 102 ⑩		6.7 93 1'		6.7 92 EP	6.8 70	6.9 50	7.0 30	7.1 18 EP	7.1 17 1'	4.6 17

℄ CULVERT NOTES

Iron	Pin	100'	Rt.	Sta. 55+00						(3685.06)		
5.8	5.3 13	3.3 25	2.8 50	3.4 81	5.4 93							
5.8		5.0 15 1'		00 4.0 21	5.0 35	5.6 60	6.3 85		7.0 96 1'			
5.8	5.0 15	7.2 15 1'		7.2 16 EP	7.3 30	7.4 50	7.5 70	7.6 95 EP		7.6 96 1'	-	F-0.5 8.1 105 ⑩

PLAN

STATION	SIZE	TYPE	CLASS	SHELL THICK	END SECTION LT	END SECTION RT	CU YD'S BEDDING MAT'L	CU YD'S CULV EXC	COVER	HEAD WALLS

CONSTRUCTION

STATION	SIZE	TYPE	CLASS	SHELL THICK	END SECTION LT	END SECTION RT	CU YD'S BEDDING MAT'L	CU YD'S CULV EXC	COVER	HEAD WALLS

End Area X Trench Width

X = Cu.Yd.Cul.Exc.

27

Removed

Inspector

Heat No's

Installed

Inspector

Est No

Entered By: | Date

Figured By:

Checked By:

Form CSN 25

Form CSN 25

Fig. 56-8: Solid Cut Section or Cut-Fill Section. Sub-grade profile is included only as a field aid for locating 00's. Note that shots are included in the payline profile 1' beyond the end-of-pipe distance.

3. A centerline rod and a rod one (1) foot past each end of pipe should be included in all profiles. The rod 1' past the end of the pipe should be labeled as such and is the last rod needed on any profile, except that a rod may be given for an offset hub. The offset rod should be clearly labeled as such and separated, by spacing, from the rest of the profile.

4. The trench width allowed for pay quantity must be noted for each culvert installation. It will be noted that a space is provided for trench width about half way down the right page.

5. Project number, project name, and project manager should be noted for each culvert or on the first page of a set of notes. Crew members, weather conditions, dates and signatures should be provided as a matter of good note keeping practice. Space is also provided to note plan and construction quantities and for any additional comments which may be necessary to give an accurate picture of the installation as noted during staking or inspection.

The result of the electronic calculation will be a listing of station, x-section area in square feet, trench width in feet, and the trench excavation in cubic yards for each culvert installation.

INSPECTION AND INSTALLATION OF CORRUGATED METAL PIPE

57.00 References

Standard Specifications: Section 54, 56, 57, and 65, and M-170

Construction Manual: III-32, IV-55 thru IV-62

Standard Drawings:

57.01 General

Corrugated metal pipe is prefabricated from relatively thin corrugated metal sheets, forming a culvert that is flexible rather than rigid. Flexible pipe does not depend on the strength of the pipe to support the loading, but rather on an even distribution of the soil pressures around the pipe. In highway construction we use two (2) types of flexible metal pipe. Corrugated steel pipe, shown on the plans as C.S.P. and corrugated aluminum pipe shown as C.A.P.

57.02 Materials Inspection

The material and the fabrication are inspected at the plant by State representatives, however, these representatives do not inspect each pipe section. A report of this general inspection which lists the manufacturer, pot number, heat number, the base metal, the brand name and the thickness of pipe that will be shipped, is sent to the project. The manufacturer will furnish a list of the pipes being shipped to the job.

After the culvert arrives on the project, it is up to the project personnel to check each pipe section to see that it is stamped with the same heat number, pot number, etc., that was listed on the original inspection report. The size and length of pipe at each location should be checked against the plans, the culvert book, and the manufacture's shipping list.

Check the cover from the top of the pipe to the finished grade elevation. Compare this height and the gage or thickness stamped on the pipe with the charts on the Standard Drawings for steel pipe or aluminum pipe. The Standard Drawing for railroad loading will not be used unless you are placing a pipe under the railroad. Manufacturers are converting to thickness in inches rather than gage. However, if you receive pipe stamped with the gage, rather than the thickness, a conversion chart is shown on the Standard Drawings.

Each pipe section is inspected by the inspector for damage from loading, unloading, or handling on the job. All badly dented or broken sections should be rejected and the contractor notified as soon as possible, so that he can order replacement pipe. If the pipe is not broken, minor dents can usually be pounded back into shape with a hammer and a wooden block. If the spelter coating or galvanizing is rubbed off the pipe, the pipe will rust easily. However, when damage is not extensive, the pipe can be hand-painted with a galvanized paint or a good asphalt compound. If the spelter damage is extensive, the pipe should be rejected.

The new light-weight three (3) inch by one (1) inch corrugations, especially in the larger size pipes, are very flexible and can be damaged if they are not loaded on the truck properly. These pipes can be worn all the way through from rubbing together. In general, if a pipe is so severely damaged that it cannot be field repaired to function as well as a new pipe, it should be rejected.

57.03 Assembly and Installation

A. General

A final check should be made on the pipe bed for grade and alignment. A quick check can be made with a level and a cloth tape at approximately ten (10) foot intervals. Installation methods will vary somewhat, depending on whether the culvert is a drain pipe, irrigation pipe, syphon pipe, or a sewage pipe. The bed for CMP need only be roughly shaped to fit the bottom of the pipe.

1. Placing and Alignment

The first section of corrugated metal pipe can be started at either the up-stream or down-stream end of the culvert. The sections are placed with the outside circumferential laps pointed up-stream and the longitudinal joints on the side, as shown in Figure 57-1, to limit water standing along a seam.

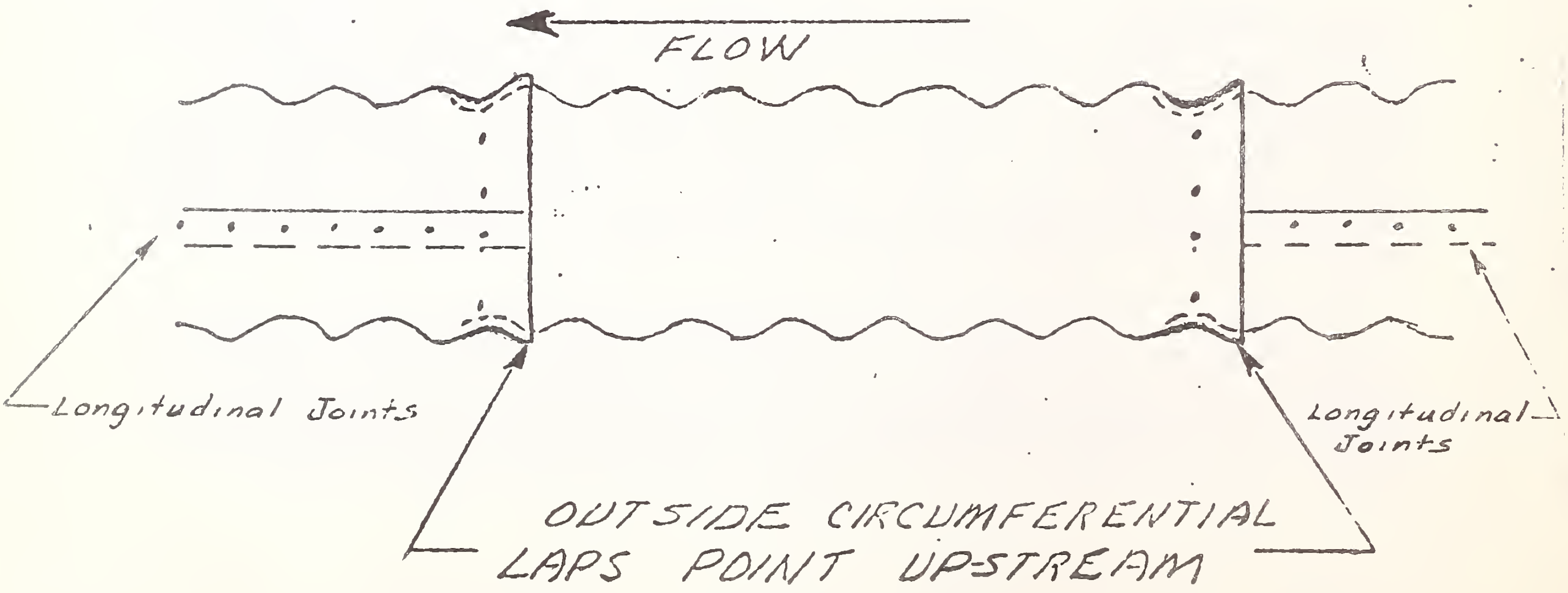


Figure 57-1

Circular or squash pipe sections are relatively easy to keep aligned. The horizontal diameter or span can be measured with a tape or rod and a plumb bob used to intersect one-half (½) the diameter to locate the top and bottom center of the culvert. A transit or string line can be used to keep the sections aligned properly. See Figure 57-2.

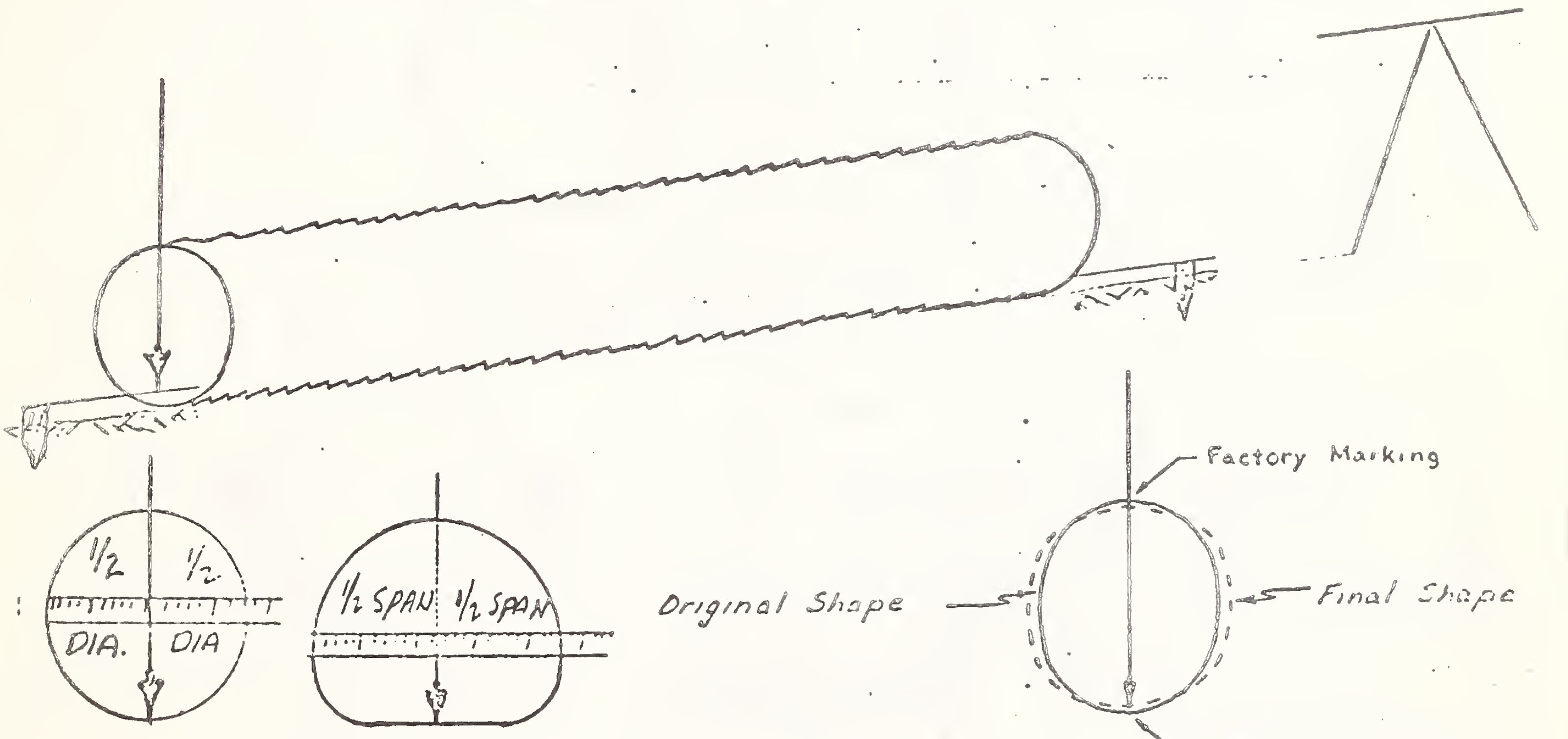


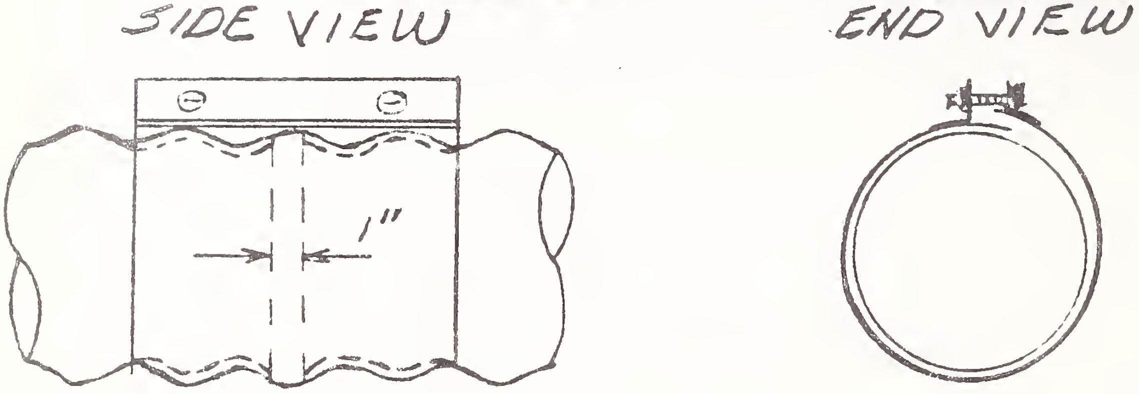
Figure 57-2

The most difficult shape to install is the elliptical pipe. If the long axis of each section is not aligned vertically within very close tolerance, the error seems to accumulate and a long installation may lay almost flat by the time you reach the other end. All pipe 48" and larger are factory shaped elliptically 5% out of round. The elliptical shape takes advantage of side soil pressures to permit the use of thinner, cheaper pipe. The centerline of the long axis, according to specifications, is marked by the manufacturer. When the long axis is marked it should be carefully lined up and exactly centered in the middle of the installation. When the pipe isn't marked, it is no simple task to find the center of the bottom and top of the pipe, some use a transit and dimension measurements or improvise a long and short axis template.

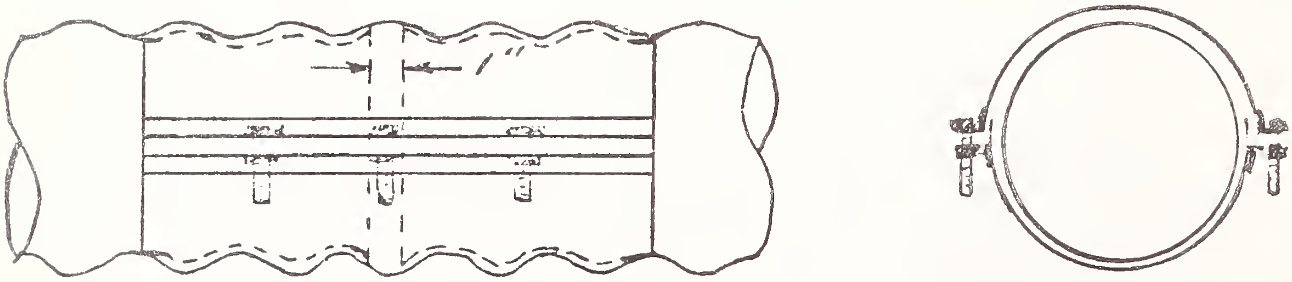
2. Connecting the Pipe

The bands used to connect the pipe take advantage of the corrugations of the pipe, either with matching corrugations or with projecting dimples that fit into the valleys. The bands illustrated in Figure 57-3 are the ones in common usage now, although the manufacturers are continually developing new bands. If there is any doubt about the acceptability of a particular type band, a sample can be sent into Helena for approval.

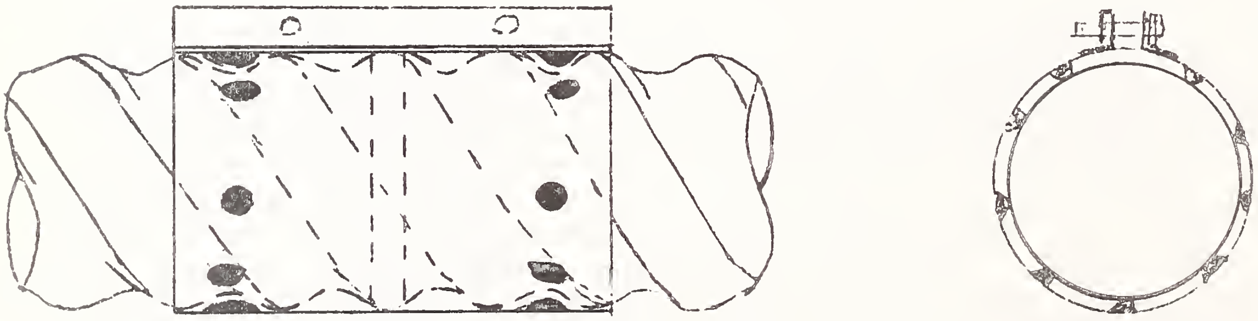
Tapping the band with a mallet as the bolts are tightened will help jar the corrugations together for a tight joint.



SINGLE PIECE CORRUGATED BAND



TWO-PIECE CORRUGATED BAND



SINGLE PIECE DIMPLED BAND

(DIMPLED BANDS CAN BE USED WITH HELICAL OR OR REGULAR CORRUGATIONS)

Minimum band width for drainage:

Diameter	Minimum Width	Type Corrugations
8" - 30"	7"	Regular
36" - 60"	12"	Regular
Over 60"	24"	Regular
Up to 60"	12"	Helical
Over 66"	24"	Helical

Figure 57-3

B. Drain Pipe

Most of our installations are in this classification. The pipe has water flowing through it during rain or run-off, but the stream flow is occasional, not constant. These locations are labeled drain pipe on the plans and the summary sheets. For example:

For Corrugated Steel Pipe	Station 10 + 00 New 24" x 60' C.S.P. Dr.
or	
For Corrugated Aluminum Pipe	Station 10 + 00 New 24" x 60' C.A.P. Dr.

All joints should be made tight. However, seams and joints on drain pipe are not required, to be water tight.

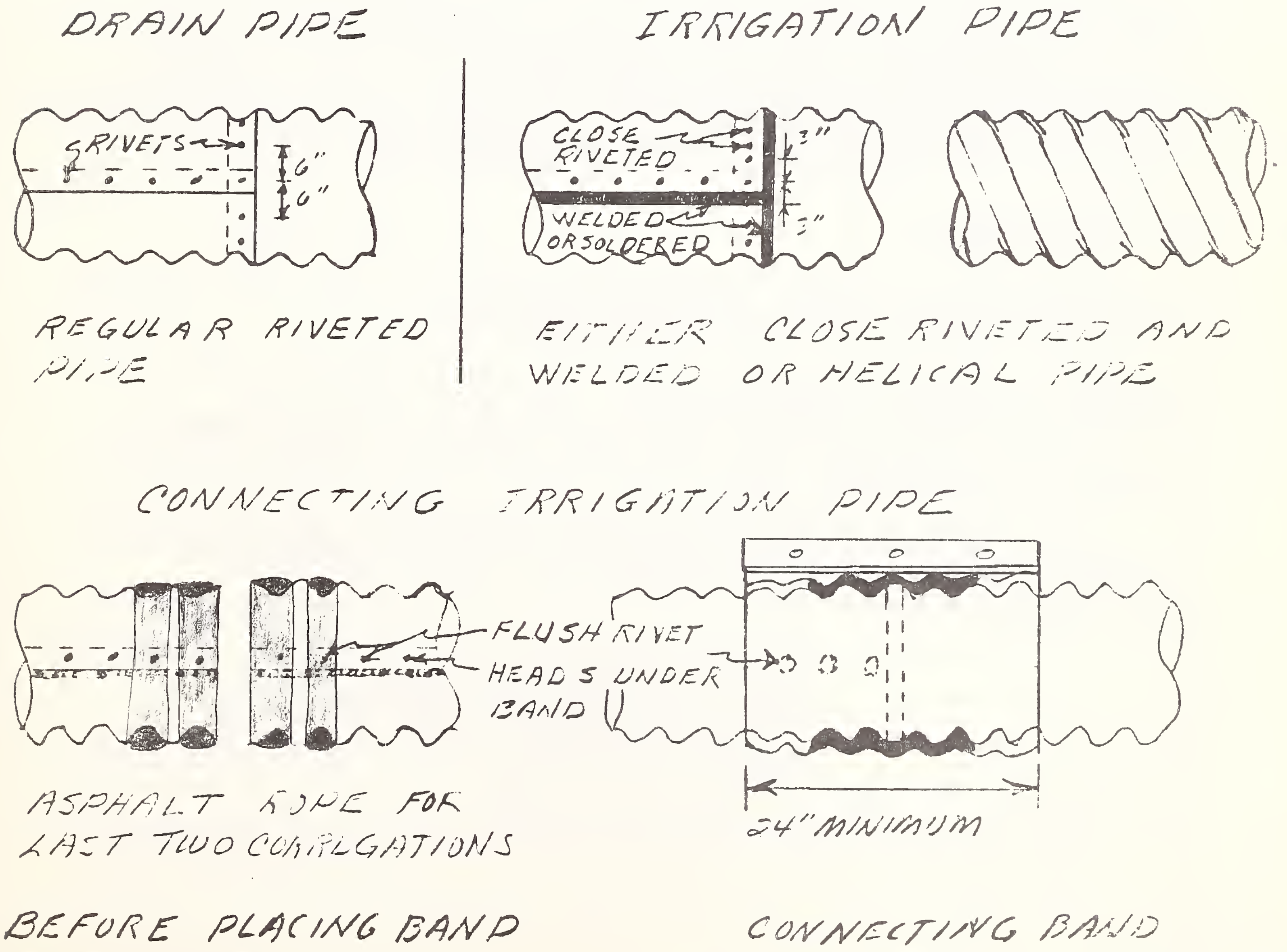

DRAIN PIPE
IRRIGATION PIPE
RIVETS
6"
6"
CLOSE RIVETED
WELDED OR SOLDERED
3"
3"
REGULAR RIVETED PIPE
EITHER CLOSE RIVETED AND WELDED OR HELICAL PIPE
CONNECTING IRRIGATION PIPE
FLUSH RIVET HEADS UNDER BAND
24" MINIMUM
ASPHALT ROPE FOR LAST TWO CORRUGATIONS
BEFORE PLACING BAND
CONNECTING BAND

Figure 57-4

C. Irrigation Pipe

Any location that has extended periods of continuous water flow either from irrigation or natural stream flow is labeled on the plans as irrigation pipe. Irrigation pipe is a designation we use to alert suppliers and the contractors that we expect water tight pipe and joints. For example:

Station 10 + 00
New 24" x 60' C.S.P. Irr.
5 C.Y. Culv. Exc.

Section 54.04 (B) of the Standard Specifications lists the requirements for metal irrigation pipe. Figure 57-4 illustrates these requirements and some connecting bands that are used. Other materials and methods for forming water tight connections may be used if approved by the engineer and the Helena Laboratory.

Flow line elevations are more critical for pipe carrying irrigation water, because the grades are relatively flat. A 0.1' error in a ten foot section of drain pipe on a 5% grade would not seriously affect the pipe, but a 0.1' error in ten feet of 0.5% grade irrigation pipe could cause the water to pond in the pipe or flow the wrong direction. A regular level should be used to set flow line elevations rather than a hand level.

D. Syphon Pipe

Syphon pipe is used when the flow line elevation of a culvert crossing is higher than the roadway section.

This situation is common across irrigated land when the roadway is in cut or shallow fill. The flow line of the irrigation ditches usually cannot be changed on either side of the roadway so the only way to get the water through the roadway is with syphon pipe.

Syphon pipe is shown on the plans, either as syphon or irrigation syphon pipe. An example of a plan listing for syphon pipe is shown below.

Station 10 + 00
New 24" x 100' C.S.P. Syph. Irr.
Instl. No. 2 - Std. Drwg. No. 56-05
S = 5.4'. S'=5.0', C=7.0', C'=6.5'
100 C.Y. Culv. Exc.

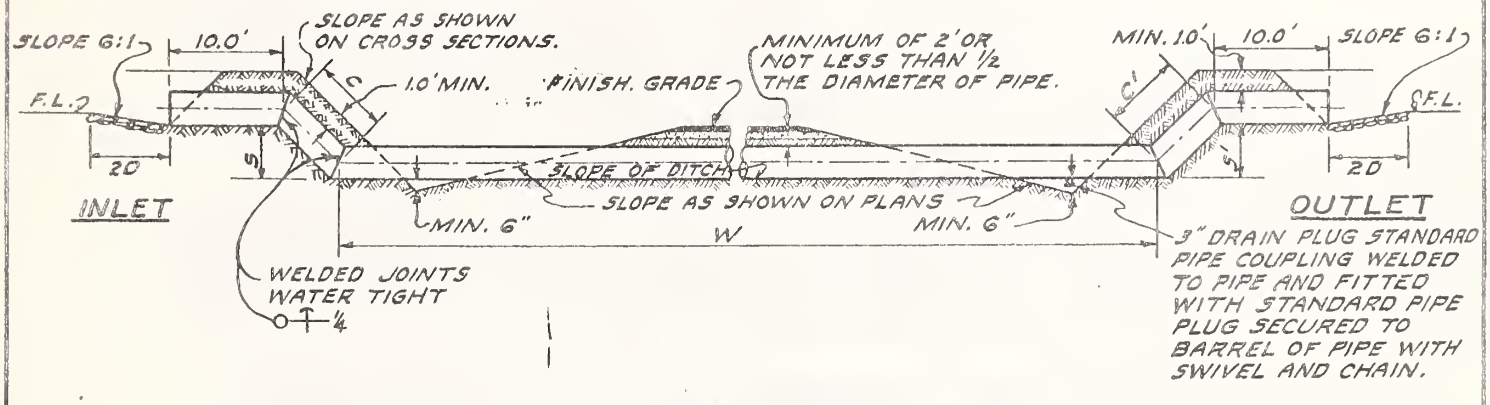
REVISED	1-1-64	11-20-68
EFFECTIVE	1-1-64	1-1-69

STANDARD DRAWING NO. 56 - 05

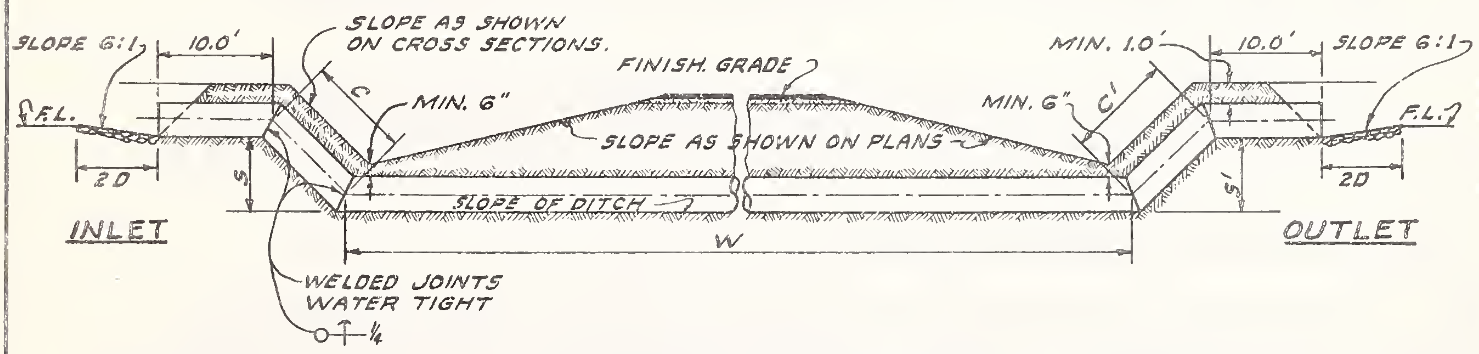
State Highway Commission
Helena, Montana

CORRUGATED METAL PIPE SYPHON

Approved
12-9-68
State Highway Engineer


SLOPE 6:1
10.0'
SLOPE AS SHOWN ON CROSS SECTIONS.
F.L.
C
1.0' MIN.
FINISH. GRADE
MINIMUM OF 2' OR NOT LESS THAN ½ THE DIAMETER OF PIPE.
MIN. 1.0'
10.0'
SLOPE 6:1
C'
℄ F.L.
2D
S
SLOPE OF DITCH
S'
2D
INLET
SLOPE AS SHOWN ON PLANS
OUTLET
MIN. 6"
W
MIN. 6"
3" DRAIN PLUG STANDARD PIPE COUPLING WELDED TO PIPE AND FITTED WITH STANDARD PIPE PLUG SECURED TO BARREL OF PIPE WITH SWIVEL AND CHAIN.
WELDED JOINTS WATER TIGHT
¼

INSTALLATION NO. 1



INSTALLATION NO. 2

GENERAL NOTES

① - ANGLES OF ELBOWS MAY BE VARIED FOR SPECIAL INSTALLATIONS TO MAKE S OR S' FIT THE SITUATION. MAXIMUM S OR S' = 15.0'.

② - ANY AREA WHERE THE GALVANIZING MAY BE BROKEN OR DAMAGE DURING FABRICATION, SUCH AS AND INCLUDING WELDED JOINTS, SHALL BE COATED WITH BITUMINOUS MATERIAL CONFORMING TO AASHO M 190.

③ - FIELD CONNECTIONS WILL NOT BE ALLOWED WITHIN FIFTEEN (15) FEET OF THE CENTERLINE OF THE ROAD.

④ - LENGTH OF SYPHON PIPE = W + C + C' + 20.0'
W = SCALED FROM CROSS SECTION.
L = AS CALLED FOR ON PLANS.
C & C' = CENTERLINE MEASUREMENT ON SLOPE.

⑤ - PAYMENT FOR PIPE TO BE MADE FOR LENGTH MEASURED ALONG BOTTOM OR FLOW LINE OF PIPE.

⑥ - HEADWALLS ~ STD. DWG. NO. 73-05 (NOT TO BE USED UNLESS SHOWN ON PLANS)

⑦ WHERE S OR S' IS TOO SHORT TO FABRICATE OR INSTALL BECAUSE OF THE RELATION OF THE DITCH GRADE TO THE ROAD DITCH GRADE OR ROADWAY GRADE INSTALLATION NO. 1 CANNOT BE USED.

Standard Drawing No. 56-05 reproduced on page 57-7 explains the terms used in the example and illustrates syphon installations very well. Installation No. 2 buries the pipe below the roadway ditch and is the favored method because too many people use the pipe for target practice when installation No. 1 is used.

The most critical part of a syphon installation is connecting the sections. The connection and pipe specifications are the same for syphon pipe as for irrigation pipe. All syphon pipes have water pressure and for this reason the connections and joints must be more carefully formed to prevent leaking. Whenever possible install the pipe and check for leaks before backfilling, syphons are not easy to make water-proof even when extra care is taken. If there are leaks they are much easier to find and correct before the pipe is backfilled.

Also, before the pipe is backfilled the inlet and outlet elevations should be checked because if the bend angles are not fabricated exactly as designed and the C and C' sections of pipe are relatively long the inlet and outlet elevation would be effected.

If the head, (S or S') is over 15 feet, a special design will be shown on the plans. Syphons with this much head build up too much water pressure for ordinary irrigation connections.

57.04 Records and Documentation

The information contained in Section 56-06 is applicable for all culvert installations. Heat numbers, gage or thickness, length, size, and type of pipe as well as any information peculiar to the installation should also be recorded. If bedding material is used, type and quantity should be noted. The notes should have dates and signatures for staking and installation as well as the initials of anyone making or checking computations.

INSPECTION AND INSTALLATION OF REINFORCED CONCRETE PIPE

58.00 References

Standard Specifications: Sections 54, 62, 63 and M-160

Construction Manual: III-32, IV-55 thru IV-62

Standard Drawings

58.01 Materials Inspection

Reinforced concrete pipe is inspected by State inspectors at the manufacturers plant, but final acceptance of material is up to the inspector. Following are items which, if deficient, can be cause for rejection upon field inspection.

1. Each section of pipe should be clearly marked with the pipe class, the date of manufacturing and the name or trademark of the manufacturer; and should be stamped with the Montana "M" in a circle.

2. Sections of pipe showing manufacture or material defects which prevent proper installation, or show damage from improper handling in transit or on the job.

3. Improper size or class of pipe - check the loading chart shown on the Standard Drawings.

A report of the pipe inspection made at the plant will be sent to the project by either the Division or the Helena Lab, and the manufacturer will furnish a list of pipe sizes and lengths being shipped to the job. The sizes, lengths, class, etc., should check with the pipe on the job.

58.02 Assembly and Installation

A. General

RCP is manufactured in relatively short (4' to 8') sections and, for this reason, positive control of alignment and grade is necessary. The use of a string line or transit for alignment and a hand level or level for grade will eliminate small errors in placement of individual sections. The small errors tend to accumulate and result in a sloppy installation. Each section of pipe should be correctly placed before placing the next section. Forcing a section that is out of line into place with backfill causes poor joints, poor alignment, and broken pipe.

Pipe bedding is the contact area between a pipe and the foundation upon which it rests. Bedding has an important influence on the ability of the pipe to support loads. The various bedding classes (See Std. Drwg.) are designed to distribute the external load that is placed on the pipe. It is important to insure that culvert bedding is constructed properly because improper bedding may result in an excessive load being concentrated on a smaller area than it was designed for. The required bedding for rigid pipe is Class C unless otherwise specified. Class C bedding is a soil foundation shaped to fit the lower part of the pipe exterior with a reasonable closeness for at least 10 percent of its overall height.

Pipe should be installed with the groove or bell end upstream and the bells recessed into the bed so that the pipe will lie evenly. (Figure 58-1) After the section is placed, you can tell whether the bed is properly shaped by how snugly the pipe fits the bed. The pipe should just touch on either side, clearing enough so that the pipe rests on the bottom of the trench. An improperly shaped bed can be further shaped if the pipe is rolled or lifted out of the trench. Never permit the contractor to shape the bed by raising and dropping the pipe.

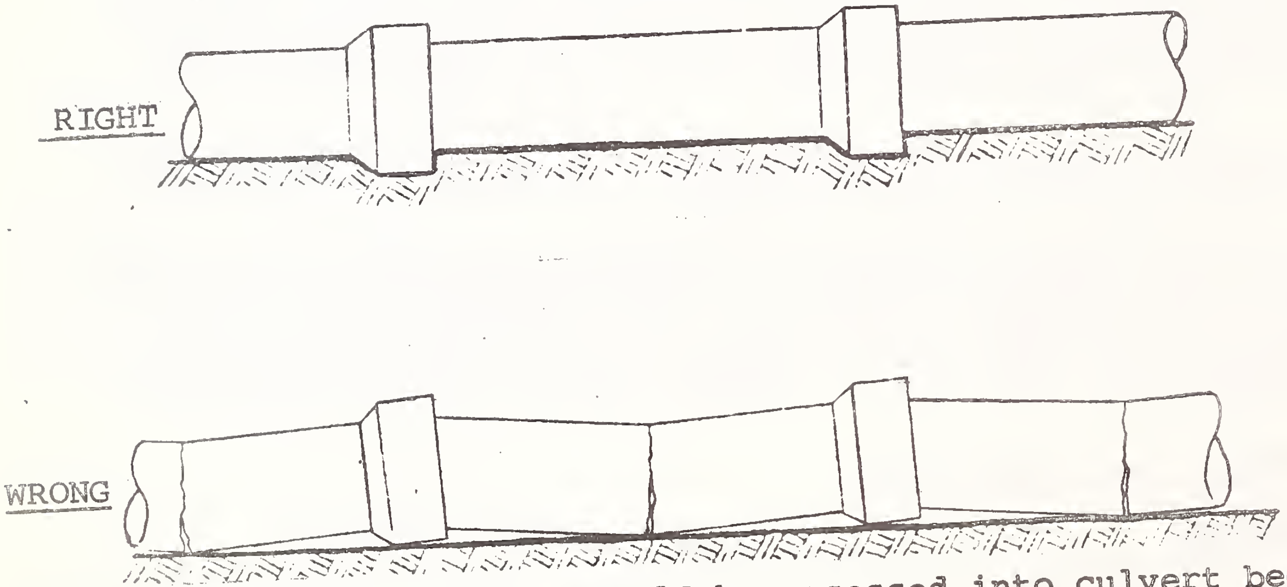


Figure 58-1: Bells should be recessed into culvert bed to properly support the culvert.

Pipe damaged excessively by the contractors' handling will be rejected. However, minor chips can be repaired with grout, if they do not impair the efficiency of the installation. The contractor should be notified, as soon as possible, of any pipe that is rejected so that he can order replacement pipe.

B. Irrigation and Syphon Pipe

Culverts used for irrigation or under periods of continuous flow of water for extended periods will be designated on the plans as either irrigation or syphon pipe and will require water tight joints. For Example:

Station 10+00 New 24" x 60' RCP Irr. 5 C.Y. Culv. Exc.	or	Station 10+00 New 24" x 100' RCP Syph. Irr. Instl. No 2 - Std. Drwg. No. 54-05 S=5.4', S′=5.0' C=7.0', C′=6.5' 100 C.Y. Culv. Exc.

Two types of joints are permitted; a rubber gasket and a flexible plastic joint sealing compound, with the exception that rubber type gaskets shall not be used on arch pipe. The rubber gasket conforms to ASTM C-443 and fits on the tongue end of the section. The difficulty in fitting this type of joint can be greatly alleviated by using a lubricant, one that doesn't damage the gasket.

The other joint seal permitted is a flexible plastic joint sealing compound that meets the requirements set forth in Section M-150 of the Standard Specifications. The compound is furnished in rope form and is easily molded or stretched around the tongue or inside the bell. Take care that the compound is placed completely around the culverts so that when the sections are pushed together the entire circumference of the connection has plenty of sealer on it. Any surplus sealer on the inside of the joint should be trimmed so that it does not impede flow. The rope diameter should be increased as the pipe size increases so that it adequately fills the spaces between pipe sections. Other types of compounds can be used, but they will require prior approval from the Helena Laboratory. Occasionally special joints and seals will be required on unusual installations, particularly in syphon pipe. This type of installation will be detailed on the plans and you will use the type of sealer that is specified.

C. Drain Pipe

Drain pipes are normally dry installations and joints may be sealed with either of the above gasket materials or with cement grout. If cement grout is used it shall conform with the requirements of Article M-150.02 (3) of the Standard Specifications. The joints should be thoroughly prewet and the grout applied to the upper half of the tongue and the lower half of the bell or groove of the culvert with a 2" overlap on each side. After forcing the sections together you will be able to see if the grout is completely around the joint. The cement grout on the inside of the joint should be wiped smooth so that it does not impede the flow.

58.03 Records and Documentation

The information contained in Section 56.06 is applicable for all culvert installations. Pipe class, type, date of manufacture, length, and size of pipe as well as any information peculiar to the installation should also be recorded. If bedding material is used, type and quantity should be noted. The notes should have dates and signatures for staking and installation as well as the initials of anyone making or checking computations.

INSPECTION AND INSTALLATION OF STRUCTURAL PLATE PIPE CULVERTS AND STOCK PASSES

59.00 References

Standard Specifications: Section 54 and 59

Construction Manual: IV-55 through IV-57

Standard Drawings:

59.01 General

The materials for Structural Steel Plate Pipe Culverts (SSPP Culverts) and stockpasses may not have been inspected by State representatives at the manufacturer. The Project Manager should inspect the materials, as per Article 59.03 of the Standard Specifications, when they arrive on the job.

The flow line grade and alignment for SSPP culverts and stockpasses, should be staked with tacks and blue-tops at about 20-foot centers, cambering the flow line as necessary to allow for subsidence. The method of putting in camber should result in a smooth vertical curve as an abrupt break in the gradeline can complicate erection and bolting of the plates. In the case of the larger sizes of pipe-arches particular attention should be given to shaping the foundation to reasonably fit the bottom (not corner) plates. This shaping can be made easier if 3 rows of blue-tops are set; one row on centerline and the other two at the width of the bottom plate on either side of centerline. The Project Manager will approve the foundation when it meets all requirements. Any pipe laid without prior approval by the Project Manager should be removed and properly relaid at no additional cost to the State.

The flow lines for SSPP stockpasses and vehicular underpasses are frequently set too low. The flow line for this type of structure need not be set as low as the flow line of a drainage structure. It should be set so that water will drain out of the structure and away from its ends. If this is not done, water may set in the underpass or collect at the ends creating a mud hole. Either situation may obstruct normal traffic through the structure.

59.02 Assembly and Installation

The specifications require that the structural plates shall be assembled in accordance with the manufacturers instructions (a copy of these Assembly Instructions for each structure should be furnished to the Project Manager by the Contractor). It is suggested that the bottom plates or flow line of the structure be completely placed before assembly of the sides and top. This does two things: First, it checks the line to see that no error has been made in the staking; Second, it checks the material to make certain the proper length has been furnished. On large diameters and heavy gages, care should be taken to get a ring completed as soon as possible. This can be done by stair-stepping the plates. This prevents the weight of the plates from folding out or in and makes it easier to bolt the top seam together.

On long SSPP installations the vertical axis of the structure should be checked as the pipe is being assembled because, in some cases, the pipe has a tendency to spiral. This spiraling is critcal for two reasons; it eliminates the effectiveness of the vertical elongation and it will result in one side of the end bevel being considerably higher than the other. The vertical axis may be kept in alignment by the method recommended for CMP that is manufactured 5% out of round (Section 57.03). The easiest and most often used method of aligning the vertical axis is by close control on the assembly of the bottom plates. The method of control is to place a straight edge across the top edges of the bottom plates and then, with a carpenters level placed on the straight edge, adjust the plates so they are level (See Figure 59-1). Then place enough backfill under the haunches to hold the bottom plates in a level position.

The plates should be assembled progressively with only sufficient bolts used to hold the plates loosely in position (these should be placed near the center of an edge and omitted in or near the corners) until assembly has been completed for four or more rings. (See Figure 59-2) When all plates are in position, all bolts not already in place are inserted and the nuts tightened progressively through the structure. Bolt heads can be placed in either valley or crest of the corrugations because of the shape under the bolt head. The curved face of the nut is always placed against the plate in both valley and crest locations. Normally, it is most convenient to place the nut on the inside of the pipe for the lower plates and the nut outside of the pipe for the sides and top plates.

Several lengths of bolts, which may be used depending on the gage of the plates and whether the seam is of 2 or 3 plate thickness, are furnished with each structure. The bolt heads are color coded for length. Extra length bolts are furnished strictly as an aid in drawing the plates together and should later be replaced by standard length bolts.

For heavy gages, tightening of the bolts is best done in at least 2 stages to prevent unnecessary scarring of the galvanizing around the bolt holes. After all the bolts have been placed, the first time over them with an impact wrench should be enough to snug the plates into place. As tightening progresses in this method, the bolts will loosen as the pipe takes shape. The second time over should give them the required torque.

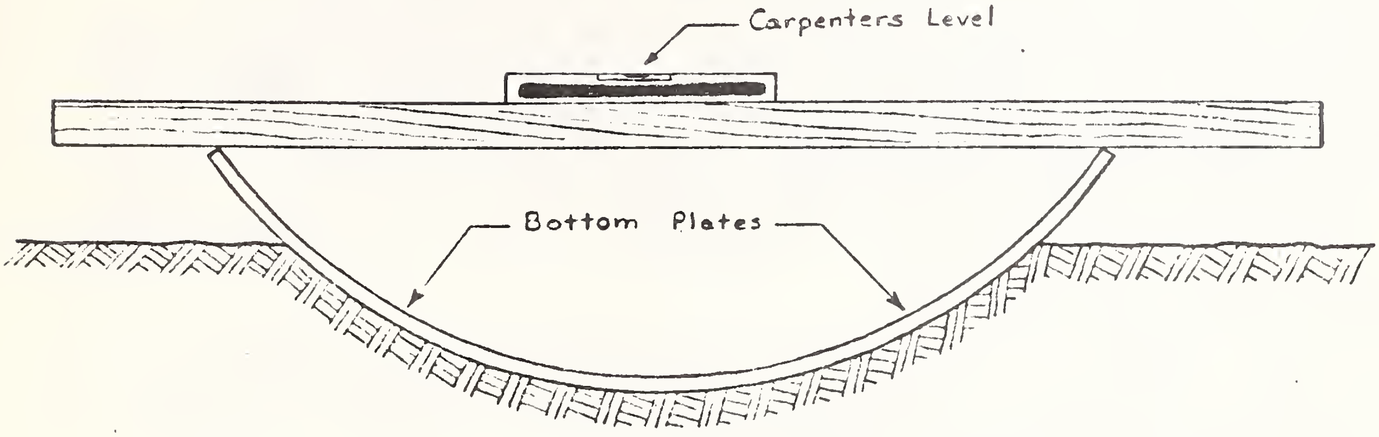


Figure 59-1. Method of assuring proper alignment of vertical axis of SSPP.

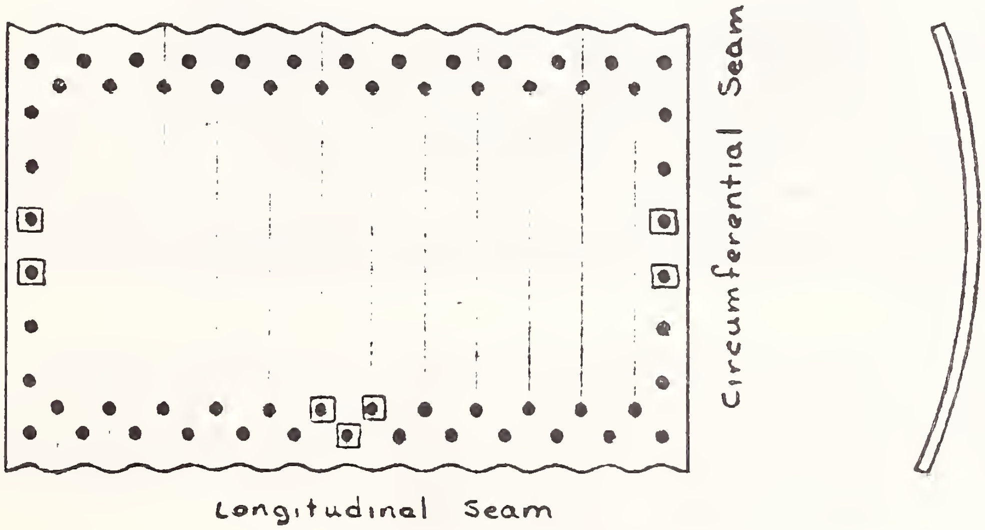


Figure 59-2 Squares indicate preferred bolting sequence, beginning at the middle and working toward the plate corners.

The long axis of ellipse must be vertical and this is best accomplished by careful and correct placing of the bottom plate for each ring. After assembly of the pipe is completed, the Project Manager should check the bolts for torque of 200 foot-pounds plus or minus 50 foot-pounds. This is done with a torque wrench, which should be available from the Division Office. It is usually sufficient to check every 20th bolt and, where tests indicate loose bolts, the bolts in that area should be properly tightened and additional tests made.

59.03 Backfilling and Compaction

The Project Manager should select the bedding and or backfill material for the haunches and sides of the culvert. Special attention should be given to selection of granular backfill material for large diameter culverts or high fills.

The Contractor should place and compact the backfill in 6-inch layers (loose thickness) under the haunches and along the sides of the culvert. Tamping under the haunches is important and is usually done by hand-operated mechanical equipment to obtain a density of 95%. (See Figure 59-3) Because of the relatively flat bottom plates, it is impossible to work mechanical tampers under pipe-arches. Here, backfill is compacted by ramming it with 2" x 4" timbers.

Backfill should be brought up equally on both sides of the culvert. Care should be taken to keep rock or hard chunks of earth in a backfill at least (1) foot away from the structure. Compaction on the sides is usually done by rollers or other heavy equipment to the required density. Compaction immediately adjacent to the sides of the culvert should be done by methods and equipment that will not distort, misalign or otherwise damage the installation. This compacted backfill should be carried to at least one foot above the top of the culvert.

Complete the fill over a corrugated steel structure using materials essentially the same as those used for the backfill and placed and compacted in the same manner. Distribute and compact the fill evenly to a depth equal to the height of the entire fill and, in trenches, to the original ground level.

Since some construction equipment is heavier than the design loading for the finished highway, culverts should be protected from overloads during construction. This can be done by an earth cover of one-half the diameter (or span) of the culvert or 4 feet, whichever is more, before allowing heavy equipment to pass over the culvert. This protective earth cover should not be "humped" over the structure since this could produce high impact loading. The surface over the structure should be level with a gradual ramp on each side.

59.04 Records and Documentation

All records and documentation required for corrugated steel pipe are required for SSPP. Any deficiencies noted during field inspection, and corrective action taken, should be recorded. Any other peculiarities of the installation should also be recorded. It is likely that the volume of information required for a SSPP installation will not fit on Form CSN 25 (Standard Culvert Note Form). When this is the case, additional sheets of x-section paper should be used as required and sandwiched between two CSN 25's acting as cover sheets.

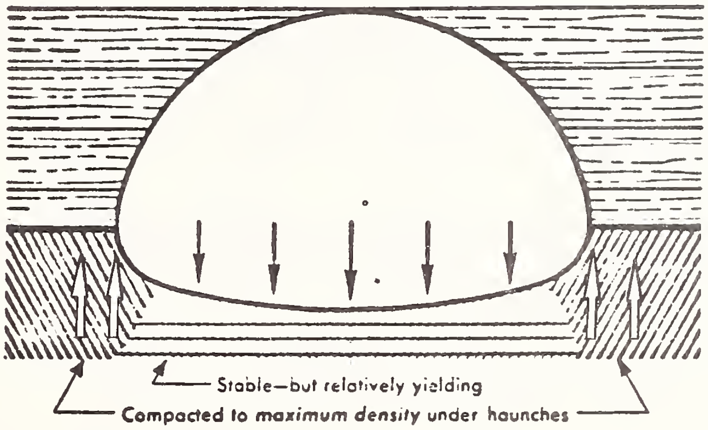

Stable—but relatively yielding
Compacted to maximum density under haunches

Figure 59-3: Compaction under the corners of pipe-arches is important.

INSPECTION AND INSTALLATION OF PIPE UNDERDRAINS

60.00 References

Standard Specifications: Section 54, 69, M-160, M-170, and M-100.12

Standard Drawings:

Construction Manual: Section IV-55, IV-56, IV-57

60.01 General

Underdrains are used to intercept and dispose of underground water that could damage a roadway. Underdrains either lower the water table or divert underground drainage away from the roadway. Underground drainage is the most likely of all drainage to be missed in a preliminary investigation. Culvert inspectors and all construction inspectors should be on the look out for underground drainage because it is often discovered during construction when excavating for cuts or excavating for culverts. Dampness or seepage usually indicate that water is not moving or is moving very slowly. This can be caused by a high water table or water slowly moving over a layer of impervious material or through a layer of pervious material. An example of faster moving underground water is a spring. Some indiciations that ground water is present are:

1. Soft, spongy ground. Water may not be visible but is usually present below the ground surface as a high ground water table, or is trapped by an impervious soil.

2. Very damp soil. Dampness that occurs over a large area is visible evidence of a high water table.

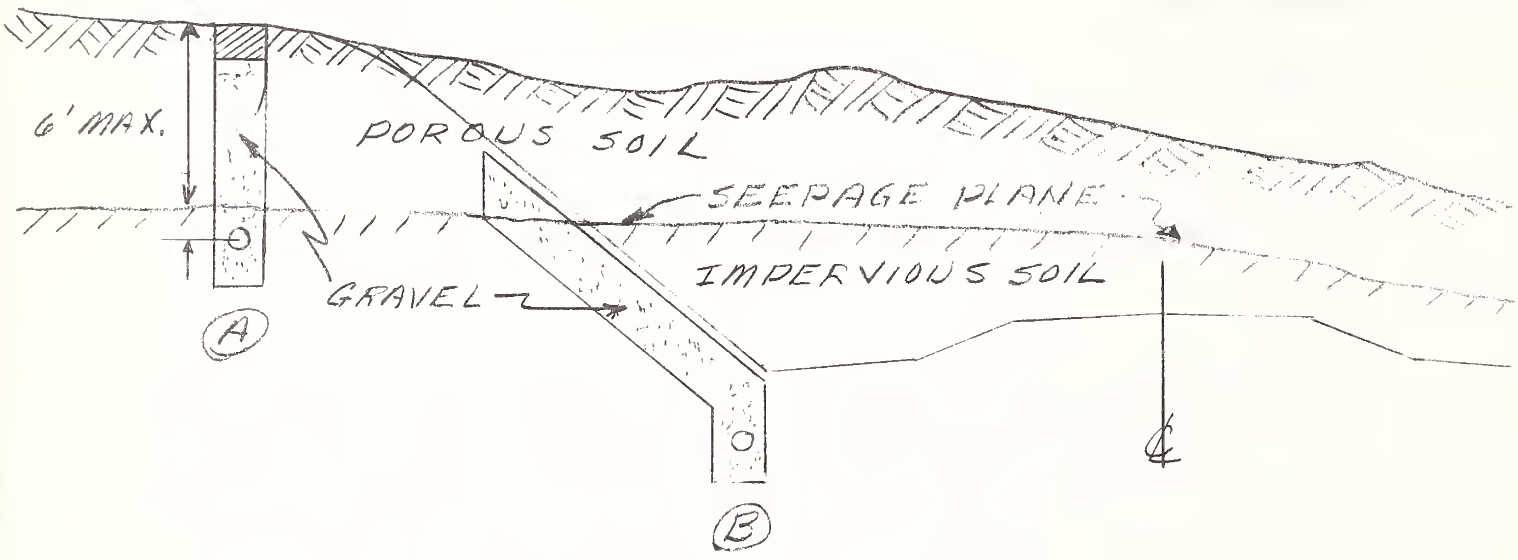
3. Re-appearing damp areas. Damp areas that appear and disappear give evidence of seasonal or periodic water movement from underground sources.

4. Soft spots. Soft spots that are repaired and then reappear are usually being replenished by more underground water.

5. A steady flow. Water that is bubbling or that is flowing steadily indicates a spring.

If any of the above signs of underground water are noticed, the inspector should tell the Project Manager so that inspection and correction can begin. Underground water can cause serious problems. Such as settled roadway, which occurs when the underlaying earth is softened by water; or frost heave, when this water freezes during the winter, forcing the pavement up; and slides, caused when water reduces the resisting forces and lubricates slide materials.

DRAINING A SEEPAGE PLANE



Ⓐ IMPERVIOUS ZONE NEAR SURFACE
Ⓑ IMPERVIOUS ZONE IS DEEP

DRAINING AN UDER WATER POOL, LOWER WATER TABLE OR PREVENTING CAPILLARY ACTION

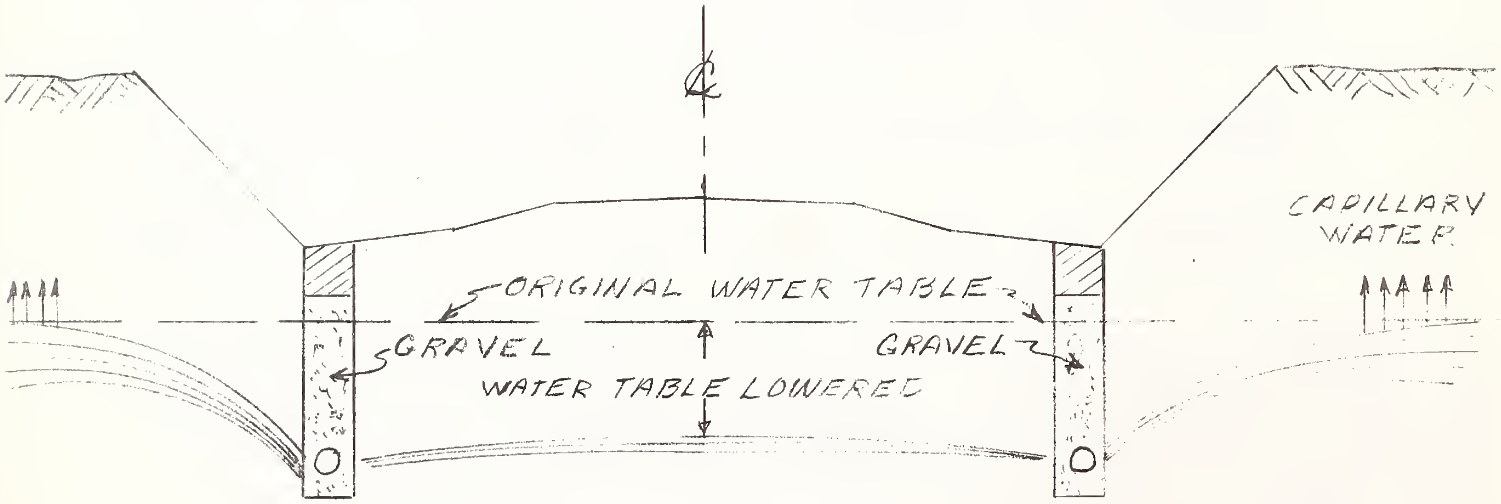
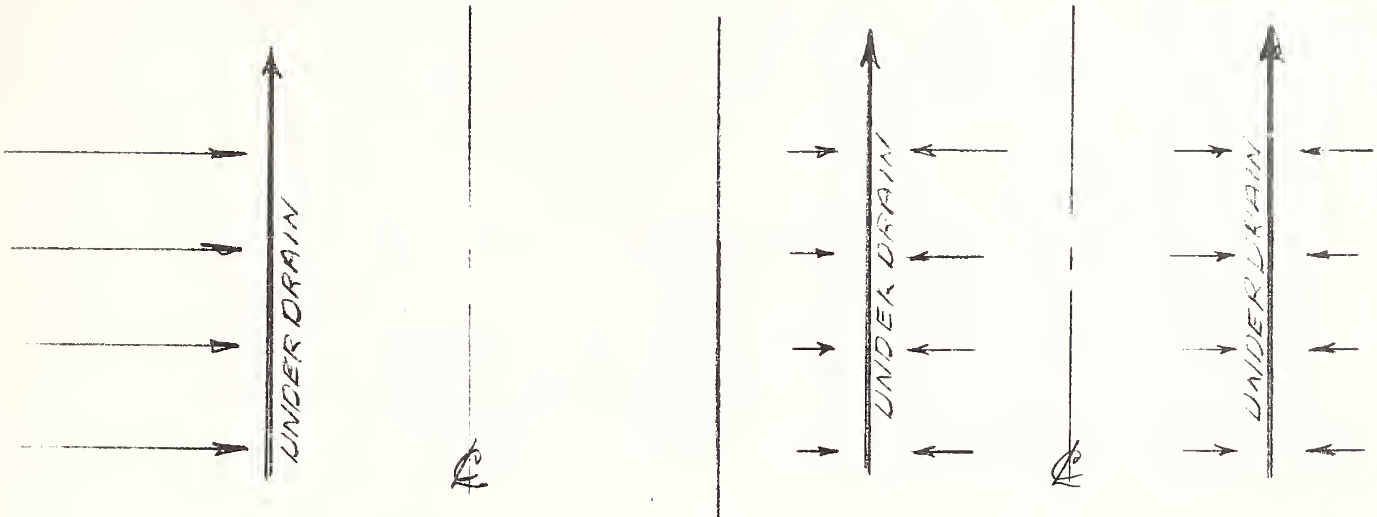


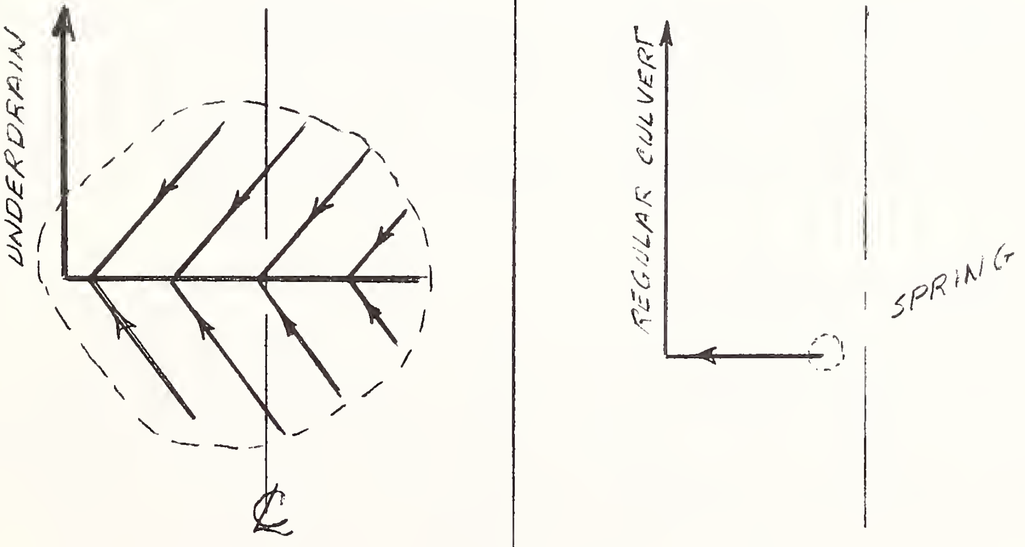
FIG. 60-1

EXAMPLES OF SUB-DRAINAGE INSTALLATIONS
PLAN VIEWS



INTERCEPTION OF UNDERGROUND WATER IN CUT SECTION - SEE FIG 60-1

DRAIN UNDERGROUND POOL OR LOWER WATER TABLE SEE FIG. 60-1



DRAINING A DEFINABLE AREA WITH A HERRING-BONE ARRANGEMENT

IF THE SPRING CAN BE LOCATED AND CONFINED - USE REGULAR CULVERT PIPE

FIG. 60-2

Figures 60-1 and 60-2 illustrate some typical installations used to drain underground water. They are intended to be examples of possible solutions. Not perfect solutions, because each installation must be designed to cure its own conditions.

60.02 Material Inspection

Underdrains are made from a wide variety of material, including corrugated metal pipe with perforations, concrete pipe with or without perforations, clay pipe and clay drain tile, bituminous filter pipe with perforations and specially designed metal pipe as shown in the Standard Drawings. The type most used in highway construction is the circular corrugated metal pipe with perforations. Figure 60-3 shows some of the different type underdrains that are available.

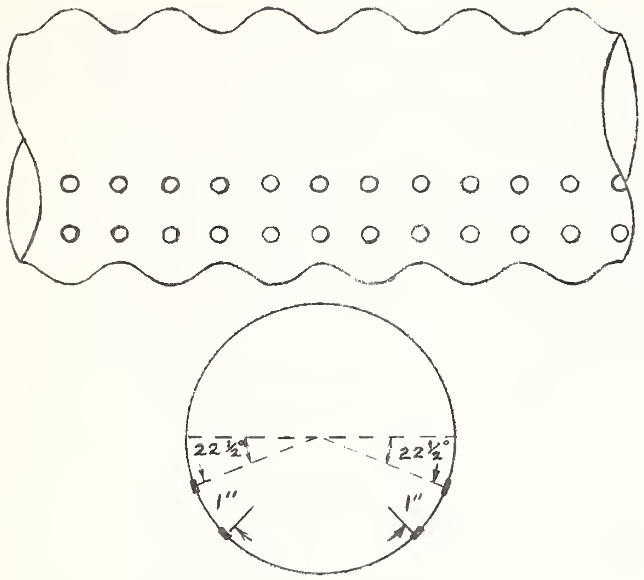
Regardless of which type of underdrain installation is called for, the materials are inspected for markings the same way as regular pipe manufactured out of the same type of material. Sections that are damaged beyond repair or broken will be rejected the same as any type of pipe.

All underground installations will be enclosed in a filter material. The filter material is used to screen out dirt which may plug the perforations or the open joints.

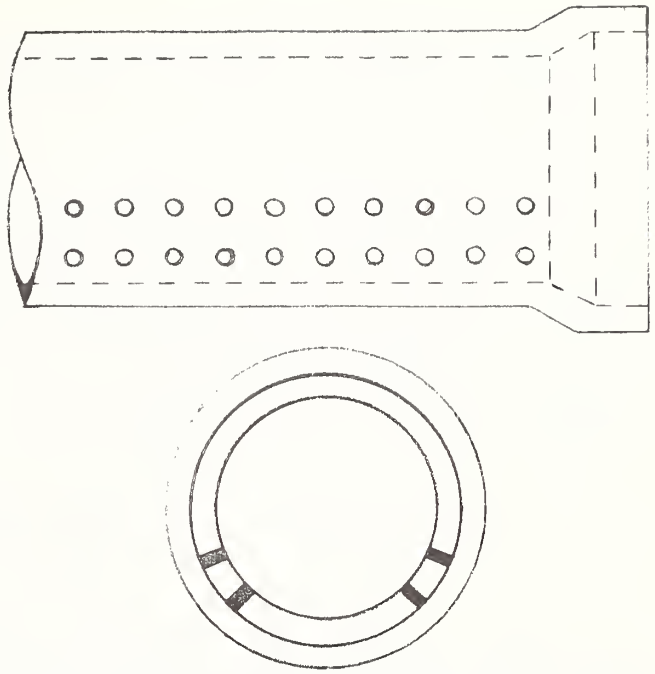
Two grades of filter material are used: #1 and #2. The gradation requirements for these two grades are shown in the Standard Drawings and in the Standard Specifications. Section M-100.12. Samples will be submitted to the Division Laboratory and regular screening tests will be made on both types of filter material and the results recorded on the standard gravel gradation forms.

60.03 Assembly and Installation

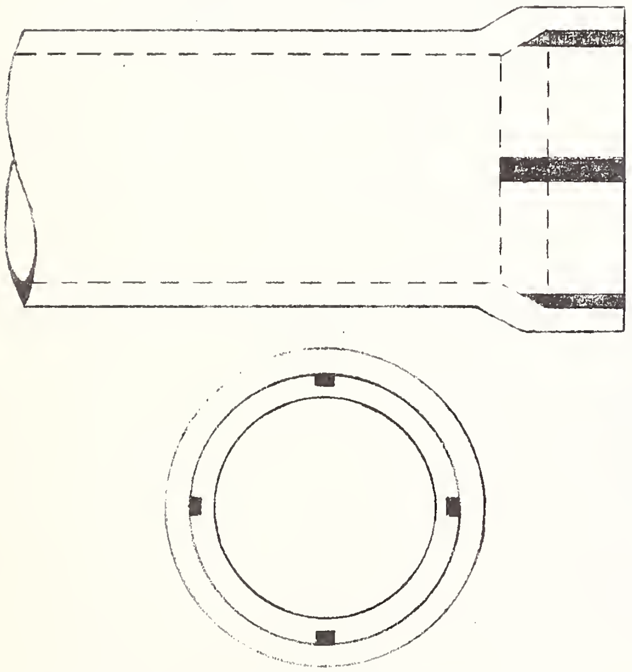
The culvert bed is prepared the same as for any culvert installation, except the excavation is one foot below the flow line grade of the culvert. A minimum slope of 0.5% is recommended, so silt infiltrating the pipe will be carried along with the flow and not plug the openings. Whenever possible, the pipe should be placed below frost line so that the pipe will not plug up with ice in the winter and quit functioning. Whenever it is possible, construction and laying of the pipe should begin at the outlet end to eliminate as much ground water as possible. The outlet end should also have a good clear outfall, so that the water can get away quickly and easily.



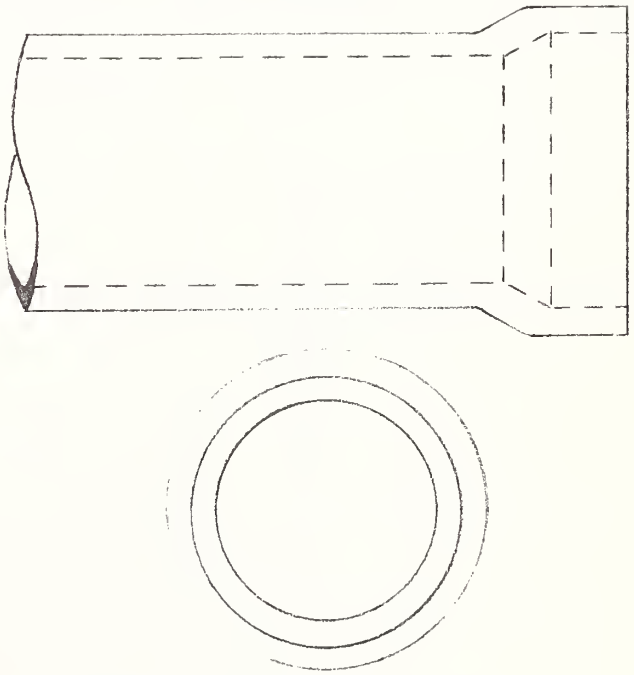
Perforated C.M.P.



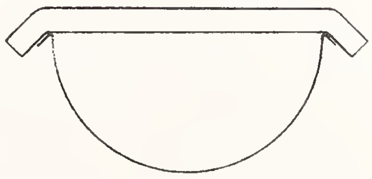
Perforated Concrete, Clay, or Fiber Pipe



Concrete or Clay pipe with lugs for centering pipe, open joints



Regular Concrete or Clay pipe to be installed with open joints



Semicircular Underdrain

Figure 60-3

If the pipe is functioning properly, there will be an almost steady flow of water, and if it does not have a good outfall it will become plugged with snow and ice or by vegetation. If a considerable amount of water flows through the pipe, riprap, or some heavy gravel should be placed at the outlet. After you are satisfied that the culvert bed is okay, 6 inches of Grade No. 1 filter material is placed in the bottom of the trench. All filter material should be placed and tamped reasonably well, but do not attempt to obtain high densities with optimum moisture, because the idea is to allow water to filter through the material. If the material meets specifications, it is well graded and does not need a lot of compaction to obtain a reasonable density and not settle.

Before placing any No. 2 filter material, pull boards are placed one foot from the outside diameter of the pipe on each side of the pipe. After the pull boards have been installed, filter material No. 2 can be placed inside the pull boards. It is a good idea to bring up the No. 1 filter material outside the pull board at the same time, to keep the boards from pushing out. The filter material No. 2 can now be fine graded to flow line elevation and is ready for the pipe to be installed. See Standard Drawings and Figure 60-4.

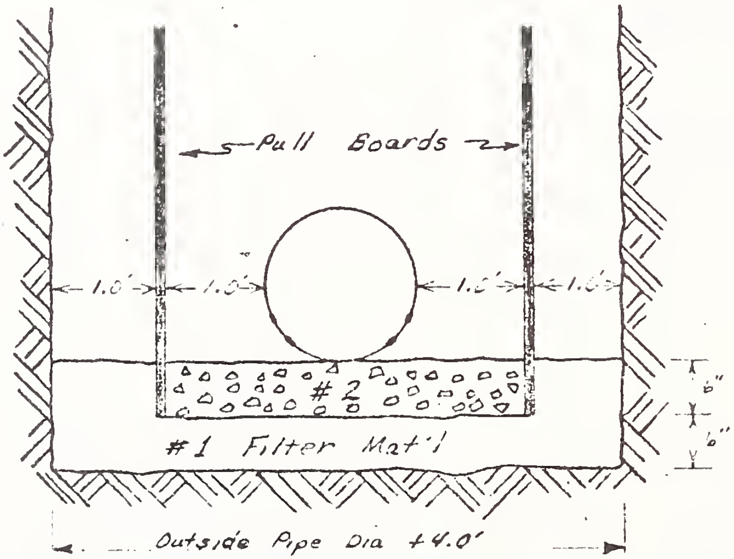
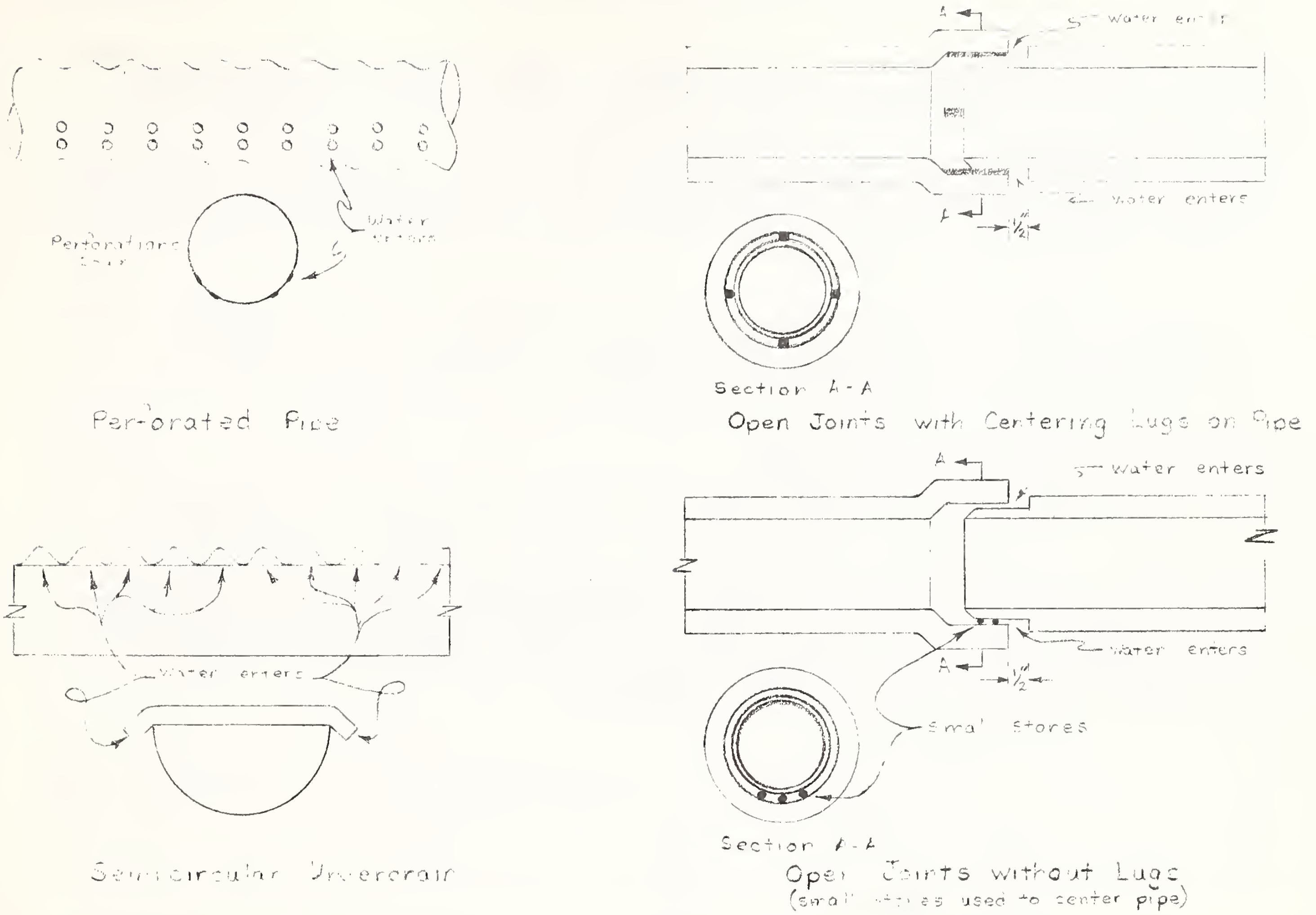


Figure 60-4

The grade line should be constructed to close tolerances, because a sag in the grade will often cause loss of water that is collected in the pipe. If perforated pipe is to be used, the pipe is laid with the perforations down. This method has been found to cause the least clogging from infiltrating material, and allows the most draw down from the water table. The pipe sections are connected together with regular pipe bands. Metal semicircular underdrain is placed with the flat side up. Concrete or tile pipe joints are left approximately 1/2 inch from closing. This allows

FOR COLLECTION OF WATER



Perforated Pipe

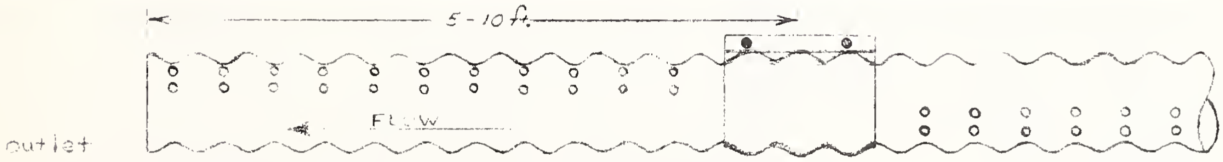
Open Joints with Centering Lugs on Pipe

Semicircular Underdrain

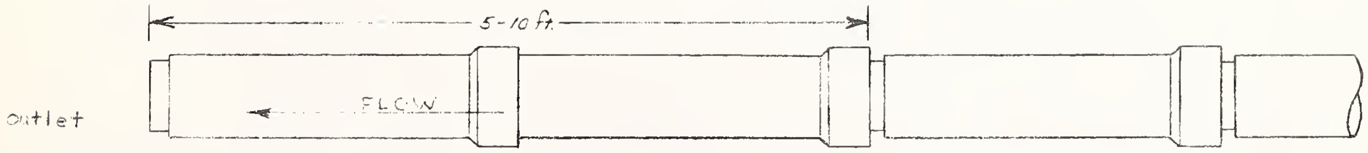
Open Joints without Lugs
(small stones used to center pipe)

Figure 60-5

WHERE COLLECTION IS LESS LIKELY THAN LOSS



Perforated Pipe: reverse perforations in the last 5'-10' to prevent washing at the culvert outlet.



Open Joint Pipe: seal joints in last 5'-10' to prevent washing at the culvert outlet.

Figure 60-6

the water to enter the pipe at the joints. The joints may be wrapped with either 4 mesh hardware cloth or burlap if the surrounding material washes easily and is likely to plug the installation. Wrapping the joints will also prevent particularly silty soil from washing into the drain through the open joints and causing a cave-in of the earth above it. Some of the methods of installing underdrains are shown in Figures 60-5 and 60-6.

Underdrains are usually in the smaller sizes, from 8 to 12 inches, and therefore are reasonably easy to install. The main thing is to have a good grade line without any sags in it.

60.04 Backfilling and Compaction

After the pipe is in place, the #2 filter material is placed around the pipe, inside the pull boards. At the same time, the #1 filter material is brought up outside the pull boards. The backfill is brought up to approximately 3 to 6 inches above the top of the pipe. Shape the #2 material in a rough semi-circle, 1 foot above the top of the pipe, as shown in the Standard Drawings and Figure 60-7 below. The pull boards are now ready to be removed.

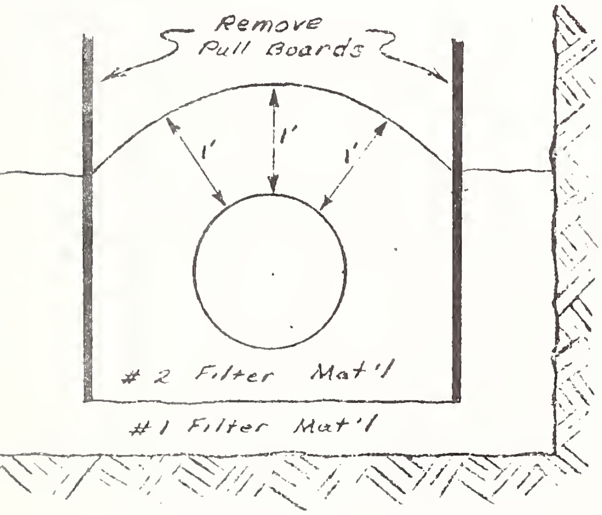


Figure No. 7

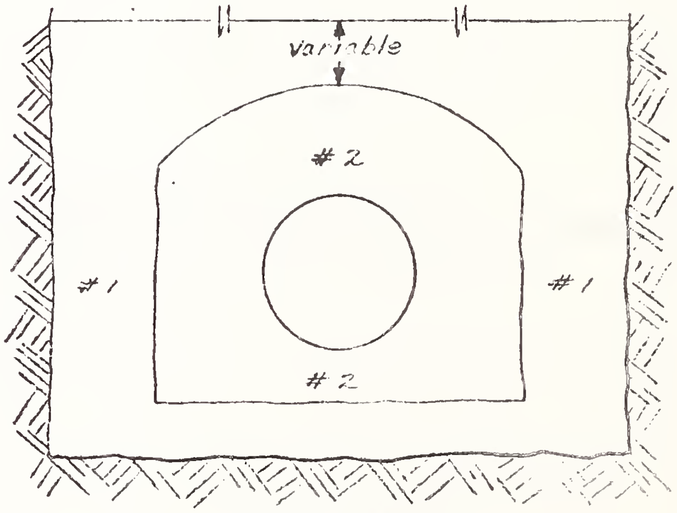


Figure No. 8

The depth of the #1 material above the top of the pipe will vary depending on the type of earth used for a cap. If the only material available is a silt or a silty sand, then the variable distance shown in Figure 60-8 should probably be between 1 and 2 feet. If a clay or other impervious type soil is available for the cap, 6 inches to a foot of #1 filter material should be sufficient to prevent excessive infiltration. The main problem with underdrains is infiltration of the finer material through the gravel surrounding the pipe and plugging the pipe. This is the reason two grades of filter material have been specified in our specifications.

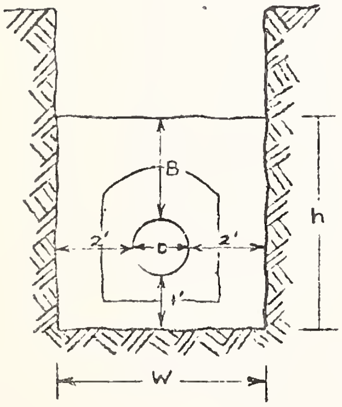
The outer, finer filter material, #1, is placed so that it will absorb any infiltration from the sides or top of the finer material and the inner area with the #2 material will be free to allow water to pass into the culvert. This is a relatively expensive design, so extra care should be taken so that the filter material is not contaminated as it is backfilled around the culvert.

60.05 Measurement

The measurement for culvert excavation will be based on the cross sectional area along the centerline of the pipe whether the pipe is parallel, perpendicular, or on a skew angle from the centerline of the roadway. The area will be from the original ground profile or from the template, whichever is lower. The width will be the same as the width used to compute the filter material.

The measurement of the pipe length will be the same as the length ordered on the revised culvert list given to the contractor. Of course if all the pipe ordered were not installed, for some reason, the length not installed would be measured as a maintenance storage item.

The filter material is not separated into grades for measurement. The item is measured and paid for as one quantity. Figure 60-9 shows the method of measurement for filter material.



D - Outside diameter of pipe, in ft.
B - Depth of filter mat'l above top of pipe, in ft.
W - Excavation width, D + 4.
h - Total height of filter mat'l above bottom of trench, B + D + 1.
L - Culvert length, in ft.
A - Cross sectional area of filter mat'l, in ft².
V - Volume of filter mat'l, in yd³.

$$A = \text{Total Area} - \text{Culvert Area} = wh - \frac{\pi D^2}{4}$$

$$V = \frac{A(L+2)}{27} = \frac{\left(wh - \frac{\pi D^2}{4}\right)(L+2)}{27}$$

$$\boxed{V = \frac{\left[(D+4)(B+D+1) - \frac{\pi D^2}{4}\right](L+2)}{27}}$$

Figure No. 60-9

60.06 Records and Documentation

The records for culvert excavation payment will be either a cross section, if the pipe is perpendicular to the centerline of the roadway, or a profile of the ground, if the installation is approximately parallel to the roadway. The notes will be signed by the original recorder, and signed by the person computing the yardage and by the person checking the computations. The inspector will record the date that the culvert was installed and when the filter material was installed and sign his name on those dates for documentation of the culvert and the filter material. Computations for the filter material should be signed by the computer and by the person checking the original computations.

REMOVE AND RELAY CULVERTS

61.00 References

Standard Specifications: Section 54 and 55

Construction Manual: Section IV-55 through IV-60

61.01 General

The main purpose in pipe removal is to salvage as much pipe as possible for re-use on the project itself, or to be put into storage for the State to use in maintenance work. A cross section, which includes elevations for all the ground breaks and the flow line elevation at each end of the pipe, is taken at the location of the pipe removal.

The method of removal is up to the contractor. The pipe inspector's concern is to see that the contractor does not damage the pipe excessively in removal. Whether the pipe is to be relaid or stored on the project for maintenance use, every effort should be made to salvage as much re-usable pipe as possible. This is much easier said than done, because the contractor is interested in removing the pipe as cheaply as possible, and the State is interested in saving as much pipe as possible. The pipe inspector is responsible for seeing that the contractor is careful in his removal. If the contractor is un-cooperative and does damage the removal pipe beyond reuse, he must replace it with an equal lengh of good pipe of the same size.

The relay location should be prepared the same as the location for a new pipe of the same type as the one to be relaid. Sometimes pipe that is scheduled for relay will be rusted through, or otherwise damaged, through no fault of the contractor. This pipe should not be relaid. The Project Manager should be notified so he can make a change order for new pipe. Some judgment is required when rejecting pipe for relay. An approach pipe would not have to be in as good a condition, for example, as a cross drain through a new roadway would.

61.02 Assembly and Installation

Relaid culverts will be assembled and installed the same as new pipe of the same kind.

61.03 Backfilling and Compaction

Relaid culverts will be backfilled and compacted the same as comparable new pipe.

REMOVE AND RELAY CULVERTS

61.04 Measurement

Measurement for payment of removal is based on the cubic yards of culvert excavation. Therefore, a cross section is required at every culvert removal. Culvert excavation will be measured in the same way as if the pipe were being installed. The width for payment will be 1 foot from the outside diameter on each side of the pipe, and for 1 foot outside each end of the culvert.

The relaid culvert will have the same information and will be measured the same way as new pipe of the same type, including culvert excavation and bedding material, if required. The length of the culvert will be the amount of culvert that is relaid.

61.05 Records and Documentation

At the removal station, the inspector should record the date of removal; the removal station; the station where the pipe is to be relaid; and the type, size, and length of the pipe removed.

The status of the full length of the culvert that is removed should be recorded in the culvert book. That is, how much of the pipe was turned over to the maintenance, how much was relaid, and how much was unsalvagable.

At the relay location, all the information that would be required for a new installation should be shown. The removal station and original removal length don't have to be shown. The relay pipe might be a combination of pipes from several removal locations.

The total length of relay may also include some new pipe. This should be recorded in the culvert book. Measurement at relay locations should agree with the information from the removal location.

MISCELLANEOUS RIGID PIPE

62.00 References

Standard Specifications: Section 54, 55, 62, 63 and 74, also M-150, M-160, M-170

Construction Manual: III-32, IV-55 through IV-61

Standard Drawings:

62.01 General

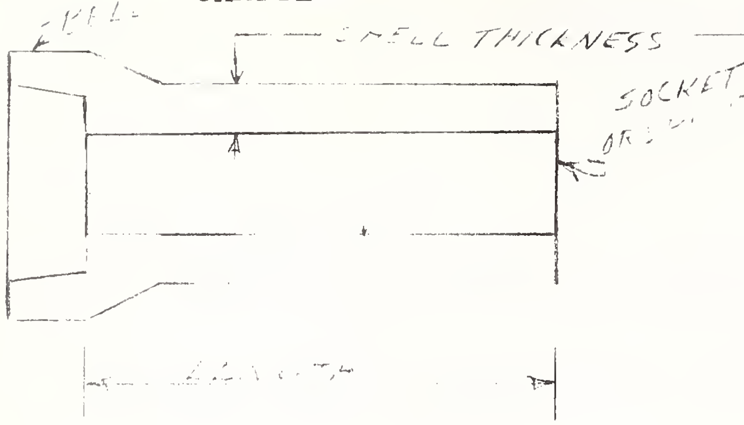
There are several different types of rigid pipe used in city sewer line and water line installations. We use these culverts when we have to tie into a pipe of this type, usually in city sections. These pipes are used infrequently on highway projects so there will not be a detailed explanation of their installation. When these types of pipe are called for on the plans it is a good idea to write the manufacturerfor his installation procedures and recommendations for joining the pipe.

All of the culverts discussed under "Miscellaneous Rigid Pipe" require water tight joints. A wide variety of joints is used for joining the different pipe together. Some of the more common are sketched in Figures 62-1 and 62-2. However, any joint that will provide a satisfactory water tight connection is okay.

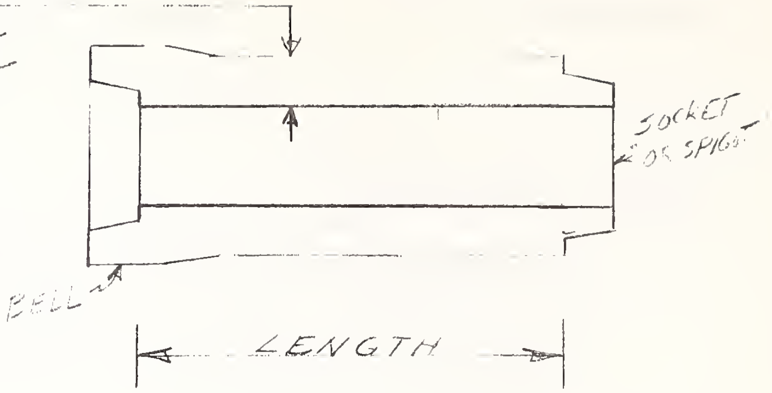
62.02 Non-Reinforced Concrete Pipe

Non-reinforced concrete pipe is manufactured the same as reinforced concrete pipe, with the exception of adding reinforcing steel. It is made in 6", 8", 10", 12", 15" and 18" diameters and in two strengths - standard and extra strength. We use the pipe occasionally for smaller size sewers. The plan designation for non-reinforced concrete pipe is "pipe concrete sewer".

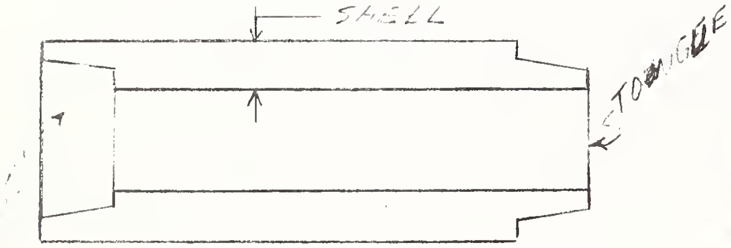
The sections are tested at the manufacturing plant by someone either from the district or Helena Lab, if it is acceptable it is stamped with the Montana "M" on each section. Rejection or acceptance is based on visual inspection of shipment damage and verification that it has been plant inspected by making sure the Montana "M" and the correct strength is stamped on the inside of the culvert. We seldom specify this type of sewer pipe unless it is to match some that is existing in an urban area that we tie into.



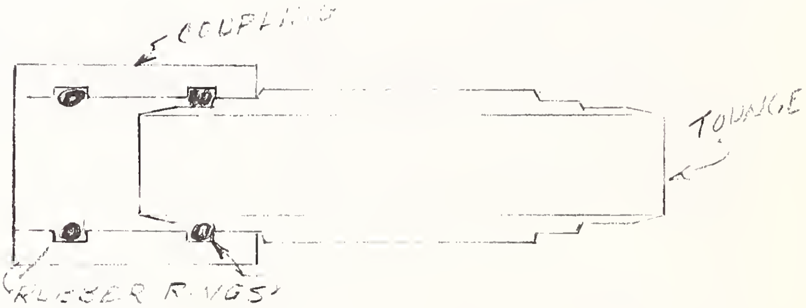
FULL BELL & SOCKET
USED IN PLAIN CONC.,
REINF. CONC. AND CAST
IRON PIPE CULVERTS



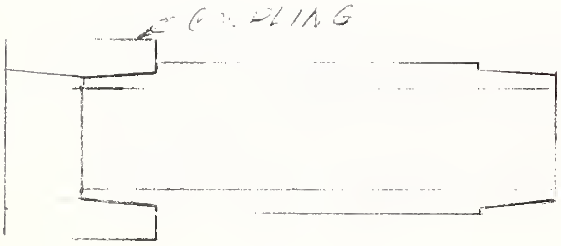
MODIFIED BELL & SOCKET
USED IN REINF. CONC.
PIPE CULVERTS.



TONGUE & GROOVE
USED IN REINF. CONC.
CULVERTS

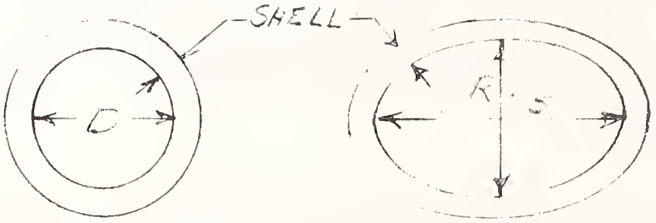


RING COUPLING
USED IN ASBESTOS CEMENT
(TRANSITE) PIPE CULVERTS



TAPERED COUPLING
USED IN FIBRE PIPE
CULVERTS

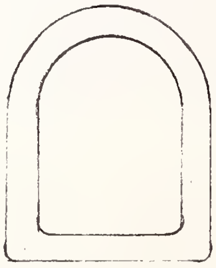
END VIEWS



CIRCULAR
CULVERT
D= DIAMETER

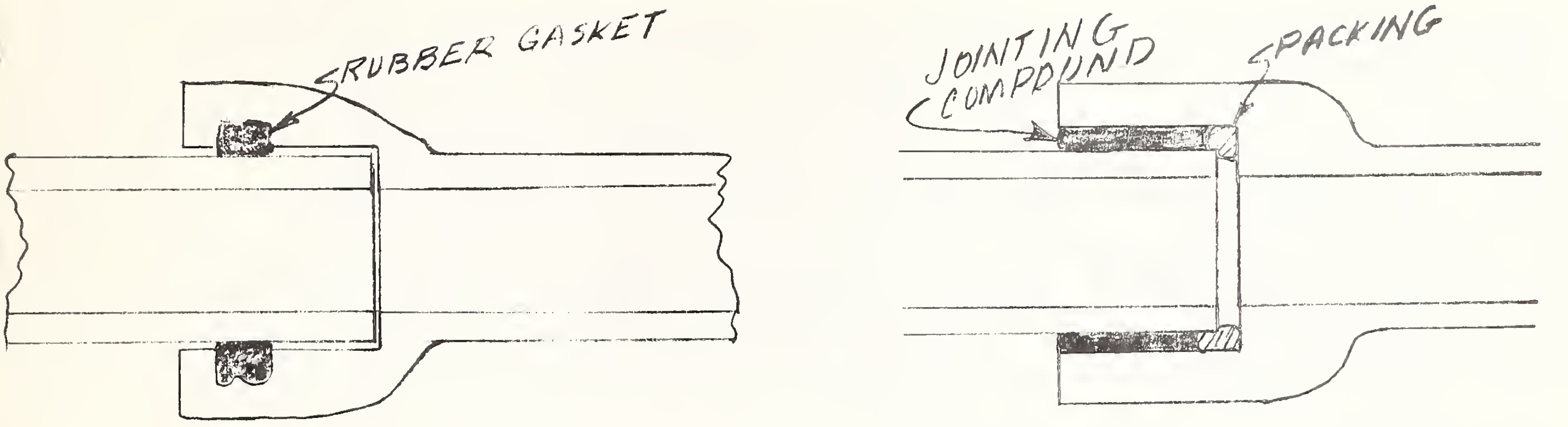
ARCH
CULVERT
R= RISE
S= SPAN

CIRCULAR PIPE ARE AVAILABLE IN ALL TYPES OF RIGID PIPE. ARCH AND STOCK PASS SHAPES ARE AVAILABLE IN REINFORCED CONCRETE ONLY.



STOCK PASS

FIG. 62-1



RUBBER GASKET JOINT USED IN CAST IRON PIPE

BELL & SPIGOT JOINT CAST IRON PIPE

FIGURE 62-2

A. Joints

The Full Bell and Socket Joint is used for non-reinforced concrete pipe. This helps maintain the full strength at the pipe joint. This joint is used in sewers requiring water tight joints, sealed with either rubber gaskets or plastic joint sealing compounds. A discussion of these joints is contained in the section on reinforced concrete pipe.

B. Shapes

Non-reinforced concrete pipe is only manufactured in the round shape with regular end sections. Flared end sections are not manufactured for this type of pipe. Another type of non-reinforced concrete pipe is the perforated pipe for guiding underground drainage.

C. Bedding

The bedding used for non-reinforced concrete pipe is the same as the bedding for reinforced concrete pipe. A complete description of this bedding is found on Standard Drawing 54-01.

62.03 Clay Pipe

Most of our clay pipe is manufactured either in Billings or in Lovell, Wyoming. It takes a special combination of clays to make clay that is right for the manufacture of clay pipe. In actual practice the usual procedure is to mix clays of different kinds to obtain this ideal combination. Enough water is added to the raw clay to make it malleable. The wet clay is then shaped in molds under pressure to make a dense solid body. Then, after a period of drying, the pipe is burnt at a temperature of 2,000 °F.

The finished product is a dense semi-glazed pipe that is the most chemically resistant pipe that is available. It is the only pipe that requires no special coating or lining to protect it from chemically active sewage, industrial wastes, some acids formed by oxidation in sewage, and from destructive chemicals in the soil. For this reason clay pipe is used for most work with sanitary sewers in urban areas. It is not used very often in highway construction because of its limited strength. Sewage pipe is usually installed in a trench condition that does not require a high strength pipe. Clay pipe is available in diameters of 4" thru 36".

A. Joints

Clay pipe is made only with full Bell and Socket Joint. New joints are being developed for clay pipe including rubber joint seals that are installed at the factory and are ready for immediate installation by simply pushing the pipe together and a joint seal made of bituminous material which is die-cast on the outside of the spigot and the inside of the bell at the factory. These joints also are simply shoved together. The older and still frequently used joint is made by pouring a melted compound around the pipe with the use of a clamp. Formerly, melted lead was used for the compound but now there are other compounds on the market. All of them make satisfactory joints when used properly.

B. Shapes

Clay pipe is made in the round shape or square ends. It is also available with perforations at the bottom of the pipe for underground water drainage.

C. Bedding

The bedding used for clay pipe is the same as the bedding for reinforced concrete pipe. A complete description of this bedding is found on Standard Drawing 54-01.

If clay pipe is used in a location not shown on the plans, the information necessary for the design of the sewage system should be sent into the hydraulics department for design. If the reader is interested in loadings and dimensions of clay pipe, he can request the clay pipe engineering manual from the Clay Products Association, Box 172, Bearington, Illinois.

62.04 Cast Iron Pipe

Cast iron pipe will be abbreviated as C.I.P. when called for on the plans. Cast iron pipe to be used for sewers will be designated as cast iron soil pipe. It is a non-pressure type pipe usually with bell and socket joints. These joints are connected the same as clay pipe using a hot compound to seal the joints. Cast iron pipe is also available for use in pressure water lines or city water supply or gas lines. These joints are usually bolted or threaded joints.

62.05 Asbestos Cement Pipe

Concrete asbestos pipe is better known under its trade name of Transite Pipe. Non-pressure asbestos cement pipe is called asbestos sewer pipe on the plans and is used for city sewer installations. It is available in strengths from Class 1 thru Class 5. When asbestos pressure pipe is needed it will be listed on the plans as Asbestos Pressure Pipe. This is available in Class 1, 2, and 3 strengths. A rubber ring coupling is used for joining this pipe together. The pipe is available in sizes up to 16 inches. The advantage of asbestos cement pipe is that it is lightweight and that it is prefabricated in 13' lengths.

62.06 Fiber Pipe

Fiber pipe is also used for city sewers. Its plan designation is bituminized fiber pipe. This pipe is also relatively light weight and is easy to handle, and to cut into any desired length.

62.07 Plastic Pipe

The various new "Plastic" pipes on the market aren't rigid in construction but will be discussed in this section because they may be encountered as water and sewer lines in urban construction. There are several different kinds of plastic pipe being used. Some of the more common names are PVC, (Polyvinyl Chloride); ABS plastic; Polyethylene; Styrene Rubber; Fiberglass; etc. Plastic pipe has been used successfully in diameters up to 40", however, diameters from 2" to 12" are most commonly used. Standard length sections for most plastic pipe are 12½' but polyethylene pipe has been manufactured in 40 and 60 foot sections. Sections are joined with couplings or bell and spigot joints sealed by a solvent weld or flexible rubber seal; or, in the case of polyethylene pipe sections, may be butt-welded together by a heating process.

Besides in urban construction, plastic pipe is being used increasingly in rest area construction. The basic cost of plastic pipe may be higher than for other materials but its lighter weight, ease of installation, and resistance to chemicals and corrosion are factors which add to its growing popularity.

When plastic pipe is used, the contractor should provide the engineer with a copy of the manufacturers specifications and recommended installation procedures.

IV-63 Curbs and Gutters

63.00 References

Standard Specifications - Sections 40, 75, M-150, M-290
Standard Drawings - 75
Materials Manual - 101 - 600

63.01 General

Curbs help define the limits of the traveled roadway, contain and direct surface runoff to catch basins, ditches or inlets and help prevent the encroachment of vehicles beyond the roadway section.

The inspector should become totally familiar with the layout of the work called for by the plans. Any necessary revision in drainage, inlet placement and grade to accomodate existing conditions, should be handled and decisions made before construction begins.

63.02 Materials

Concrete curbs and gutters will be made with "DD" concrete and meet the requirements of Section 40. Reinforcing steel and joint material should conform to Sections M-290 and M-150.

Bituminous materials should conform to Sections 30 and M-120. Bitumen will be 60-70 penetration asphalt cement or that specified in the pavement mix.

63.03 Construction

(A) Concrete Curbs

(1) Foundation and Preparation of Forms

The plans will generally require that the concrete be placed on a well-compacted crushed base course. Prior to placement of the crushed base, the existing soil must be brought to proper grade and compacted. Be sure that any soft, muddy spots are removed and replaced with stable, well-compacted material.

Inadequate or non-uniform compaction will result in curb settlement which in turn creates a drainage problem and expensive maintenance.

Check to see that forms are set to proper line and grade by measuring from the offset stakes and sighting along the top of the forms. Badly dented or damaged forms should not be used. Forms must be adequately braced to resist the outward pressures that develop in placement of the concrete. All forms shall be mortar-tight.

Forms should be oiled, this will help prevent the concrete from sticking to the face of the form. Excessive oiling will discolor the concrete.

Inspect the expansion joints, dowels, tie bars and reinforcement for proper location, size, laps and ties and be sure the steel is firmly in place.

(2) Placing Concrete

An inspector is needed at the point of batching to assure that the correct portions of cement, fine aggregate, coarse aggregate and water are being furnished.

The specifications are to be closely followed on recommended mixing times and maximum allowable elapsed time between mixing and placing.

Immediately before concrete is placed in the forms, the granular material on which the concrete will be placed should be thoroughly dampened but do not let concrete be deposited in puddles of water. During hot weather, the aggregates and forms may require cooling by prewetting to avoid excessive loss of moisture.

The concrete should be placed in the forms in its final position with a minimum of shifting or manipulation of the mixture. The material should be vibrated only to form a dense well-compacted mass.

Vibrating along the edge of the form will help to eliminate voids and unsightly rock pockets but over-vibrating will work the larger rocks to the bottom and the fine material to the surface. Each manipulation of the surface tends to bring up fines, which if accumulated in excess (laitance), can later cause surface defects. The Standard Specifications in Section 41.04(E)show the steps to be followed in using a vibrator.

(3) Finishing Concrete

On most projects the contractor will utilize a curb finishing machine. Immediately after the concrete has been deposited the machine travels along the forms and shapes the concrete into the specified curb design. The concrete is also vibrated at the same time.

The curb should be carefully inspected to be sure that the correct curb shape is being produced. The speed of the machine must be carefully controlled or the desired results will not be obtained and more handwork will be necessary.

If the curb machine works correctly little handwork is required other than floating and edging. The curb should be floated with a wood float just enough to bring the fines to the surface and to remove any irregularities. After floating and just prior to applying the curing compound the surface of the curb should be brushed lightly to obtain a uniformly textured surface.

On curb returns and laydowns the curb machine cannot be used and the finishing must be accomplished by hand methods.

When the curb must be finished by hand, care must be taken so that the desired shape is obtained, flow line of the gutter is in the proper location and has the correct depth. The surface of the gutter should be checked closely with a 10 foot straight edge so that any irregularities can be corrected at the start of the finishing.

At the completion of the floating operation, there may be free water on the concrete surface that has worked up during the settlement and consolidation of the rock. Delay further finishing until this water has evaporated and do not permit sprinkling of sand and cement mixture on the surface to absorb this excess water.

Edging work can begin as soon as the water has nearly left the surface. An edging trowel produces the rounded or beveled edge, at the top of the vertical faces. Edging helps prevent spalling and chipping and also provides a pleasing appearance. Contraction joints can be formed as required at this time also.

(4) Joints

Expansion joints are spaced evenly between curb returns with a minimum spacing of 30 feet and maximum spacing of 50 feet. The joints must be completely filled with a minimum of ½ inch of preformed expansion joint filler. The joint filler material is set-in the forms prior to placing the concrete. Care should be taken that the expansion joint material is not displaced from its location and that it remains vertical.

Contraction joints in the curb are placed at approximately 10 foot intervals. These are formed by placing a sheet of metal in the forms prior to placing the concrete. These are then removed before the concrete sets and the joint edged.

Forms are to be removed after the concrete has taken its initial set. Minor defects in the surface shall be repaired at this time with a mortar consisting of one part cement to two parts of fine aggregate. Form markings are to be erased.

(5) Curing

Concrete that drys too soon will not have a lasting durable finish, or the necessary strength.

After final finishing and while the concrete is still moist, it shall be covered and cured as outlined in the Standard Specifications in Section 40.05(E).

If a curing seal is used be sure it is applied slow enough and at a steady rate so all surfaces have a uniformly thick cover.

(6) Testing

Check the slump, air content and make the cylinder in accordance with instructions for these tests in the Materials Manual.

(B) Asphalt Curbs

Curbs to be built from asphalt concrete are small in mass and in some cases, a special mix is needed. The mix usually used is the same as that of the asphalt pavement unless directed otherwise by the engineer. In order to perform well, the mix shall have the proper stability, cohesiveness, and should be capable of being compacted to a dense mass.

If adjustments are to be made in the mix it has been generally found that a gradation on the fine side of a standard mix is preferable to a more open specification. Also, in many cases, it is found that the temperature of the mix at time of placement is critical. An excessively hot mix may tend to flow, while a mix on the cold side may be difficult to work.

Prior to actual construction, the inspector should make a field check to make sure that the proposed curb alignment and locations are clearly marked out.

The inspector should give special attention to assure proper horizontal and vertical alignment. If improper construction, such as rough or irregular alignment occurs, the curb should be subject to rejection and reconstruction. Good and proper workmanship is to prevail at all times.

The surface of the pavement should receive a tack coat of asphalt just before the curb is placed.

Additional details on mixing and placing can be found in the section on Plant Mix Pavement.

63.04 Records

A complete inspection is to be made. If any discrepancies are noted, the contractor must make the necessary corrections before the work will be accepted.

Records should show date forms were ready, dates concrete was placed, inspector and major work inspected, weather conditions, quantities placed with each shift, major corrective action taken (if any) and records of other items as they occur. For instance aggregate and cement test results, should be on file, and cylinder test results maintained.

IV-64 Fence

64.00 References

Section 80, 81, 83 and M-210 of the Standard Specifications

Standard Drawings Nos. 80-01, 80-02, 81-01, 81-02, 81-03, 83-02

64.01 General

Most of the fence constructed by the Montana Highway Commission consists of three types: Chain link fence, wire fence and farm fence.

The greatest use of chain link is for control of access fence within city limits. Some use for chain link fence is also found in rest areas and other special cases.

Wire fence is used mainly for right-of-way boundary fence in rural areas on Interstate projects.

Farm fence, as its name implies is used to replace present barbed wire farm fences or to enclose previously unfenced land along the right-of-way on primary and rural roads. Either barbed or woven wire can be used.

There are several types of fence that are used for special applications. Examples are median barrier fence, rock barrier fence and snow fence.

Questions about the fence location; length to be fenced; need of temporary fence; and when fencing is to start and be completed, do concern adjoining landowners as well as the State. The Resident Engineer should make a careful review, of the agreement for each parcel of land requiring fencing, just as soon after the job is awarded as his schedule will permit.

64.02 Materials

Materials for chain link and Interstate wire fence have more stringent requirements for quality than do the materials for farm fence. Farm fence materials are acceptable if they meet specifications described in the usual commercial standards or pamphlets on simplified practice. Chain link and Interstate wire fence materials must meet ASTM requirements. The differences in fence types are spelled out in Section M-210 of the Standard Specifications.

Materials that have been inspected by a representative of the materials laboratory at the factory or place of production should bear marks of inspection and by supported by test reports. Materials not pre-tested must be carefully examined on the job. Do not accept a pre-tested material that has become damaged or is actually inferior and unacceptable, just because it has the "circle M" stamp.

64.03 Construction

A. Layout - All Fence Types

Check the Standard Drawing pertaining to the type of fence being installed for guidance in layout work. The right-of-way plans must show the same requirements as the right-of-way agreements or allow for construction according to these agreements.

Try to set the distance between panels at 16.5 feet so that an even number of rods will occur. When this can not be done, the odd length should be absorbed near the center of a run (rather than at the end) by increasing the spacing of a few posts.

After the fence alignment has been reviewed, and staked, the contractor will clear the ground of all obstructions such as stumps, brush, trash and humps. A bulldozer may be used but unneeded clearing is to be avoided. Areas visible to motorists where dozer clearing would be unsightly should be cleared by hand. Bottom wires should not touch the ground so be sure high points are removed.

B. Post Holes, Backfilling & Setting Posts

Holes for corner and end posts that will be set in concrete should be round and flared at the bottom. If no dimensions are shown in the standards for the type of fence desired, the hole should be about 12 inches wide at the top, about 18 inches wide at the bottom and about 3½ feet deep.

Holes made for concrete footings are to be moist when the concrete is placed, Dry earth will rob moisture from the mix that is needed for proper setting.

When concrete is specified or directed use Class "F". Class "F" does not require testing of materials in the usual manner, the engineer can accept materials on the job. Just enough water should be used to make the mix workable. Too much water causes a soupy mix and loss of strength and decreases durability.

The top of the concrete is to be "crowned" for drainage. Curing should continue for at least 7 days before stretching the wire or putting stress on the concreted post.

Most holes can be started and completed with a mechanical post hole digger or auger but in rocky ground it may be necessary to blast. Blasted holes need good cleaning and carefull backfilling to insure a solid installation. Blasted holes should have concrete backfill if the usual backfilling method does not provide a solid post.

All posts should be set at the depth shown in the Standard Drawings. If depth requirements are not shown or specified, wood posts should be set about 30 inches deep. Backfill soil should be moist and placed in successive layers with each layer thoroughly tamped before the next layer is placed.

Special care is needed in preparing the ground profile and setting posts for chain link fence in order that alignment is true and will present a smooth appearance. Before the concrete takes its initial set, each post should be plumb and checked for elevation and alignment.

C. Panels

Panels are the "anchor" for runs of fence. Strong vertical post installation is the "backbone" of the panel so their proper construction is vital. Concrete around steel posts must harden before any stretching or pulling is done. Wooden posts are to be made solid by setting at least three (3) feet in the ground and thoroughly tamping the moistened backfill soil.

Check the Standard Drawings for details about materials, dimensions, lengths of run and the like.

1. Panel for Chain Link - A panel for chain link fence is composed of a brace, a truss rod and use of a brace post. Tension from the fabric is transferred through the truss rod to the brace post. Braces and truss must be securely fastened to the post before erecting and tightening the fabric in order to absorb the tension. Double panels are required at least every 300 feet on tangents, at the end of curves sharper than 5° and a maximum of every 250 feet around curves.

2. Panels with Steel Posts - Steel posts are set 38 inches deep in a concrete footing. Brace posts are attached at an angle to the vertical member and set in a concrete footing. Two (2) braces constitute a double panel. One brace makes a single panel.

3. Panel with Wood Posts - Posts for panels are 1 foot longer than are line posts. This extra length is set further into the ground than are line posts. The wood brace acts as a compression member. The diagonal brace wires transfer tensile forces from the fence to the bottom of a post and from there into the ground leaving the twisting levers in place to be sure the twisted wire remains tight.

   There are three (3) types of wooden panels; a single, a double and an end panel.

4. Runs of Fence - The run for chain link is as stated above. For fence with steel or wood posts the run is as follows.

FENCE TYPE	RUN	PANELS REQUIRED
WOVEN	33' or less	None
	33' to 330'	Single or End
	Over 330'	Double
	Maximum run = 660'	
BARBED	66' or less	None
	66' to 660'	Single or End
	Over 660'	Double
	Maximum run = 990'	

D. Installing Wire

Be sure high spots or obstacles that will interfere are removed. The wire should be from 1" to 2" above the ground for chain link, about 12" for median barrier fence, about 3" for woven wire, and from 9" to 16" for barbed wire.

Fabric for chain link fence is fastened to the various posts and rails by tie wires, metal bands or stretcher bars as shown below.

FASTENING CHAIN LINK FABRIC

Fabric Fastened to POST, WIRE OR RAIL	Fastener	Fastener Spacing
End, Gate, Corner & Pull Posts	Stretcher box and fabric bands	1 foot interval
Line Posts	Tie Wire, Metal Band or Approved Method	14 inch interval
Top Edge of Fabric to the Top Rail or:	Tie Wire	18 inch interval
Top Tension Cable	Tie Wire	30 inch interval

Woven and barbed wire are fastened to wood posts by staples and to steel posts by metal clips. Fasteners are spaced as follows.

FASTENING WOVEN OR BARBED WIRE

Post Type	Wire Type	Spacing of Staples
End Pull or Tie-Off Posts	Woven	Top, Bottom & Alternate wires
	Barbed	Each Wire
Line Posts	Woven	Top, Bottom & Alternate wires
	Barbed	Each Wire

When stapling woven wire, the top and bottom wires on each post should be stapled first. A uniformly tight fence can be obtained more readily by starting midway between corners or ends and stapling toward each end. On level ground and over knolls the staple should slope slightly downward. In draws where the wire tends to lift, the staple should slope upward into the post. Do not allow staples to be placed over or next to the barb or the stay wire. There must be sufficient room to allow for free movement through the staple. Movement is caused by expansion and contraction.

The wire at ends where it is tied off should be stapled and wrapped around the post then fastened back on itself. Enough barbs or stays should be removed to allow for wrapping the wire around the post and for making a tight wrap-splice back on the wire.

When multi-strand barbed wire fence is to be attached to an anchor post the top wire should be attached first. This method will put the maximum pull on the top of the anchor-post. The lower wires can then be added without loosening the first wires.

64.04 Contractor Co-operation, Contract Time and Insurance on Fencing Contracts

On many projects where fencing and grading are a separate contract, it is important to complete most of the fencing work prior to completion of the grading. Contractors involved should cooperate and coordinate their activities in order to accomplish this. The fencing contractor normally has only 30 days, after notification that contract time will begin, to complete all fencing work. If fencing work is delayed until grading is nearly complete a hardship will be created for the fencing contractor.

Insurance is a costly item on a relatively small contract. The contractor may either delay acquisition of railroad protective insurance until shortly before he will be able to perform his work involving entry on railroad right-of-way or he may complete that portion of work prior to expiration of his insurance.

Contract time, co-operation and insurance matters should be discussed at the Preconstruction Conference. If procurement of insurance is delayed because work will not be started for some time, send notice to the Construction Division immediately. Arrangements will be made with the Commission Secretary to have the insurance delayed until needed.

64.05 Inspection and Records

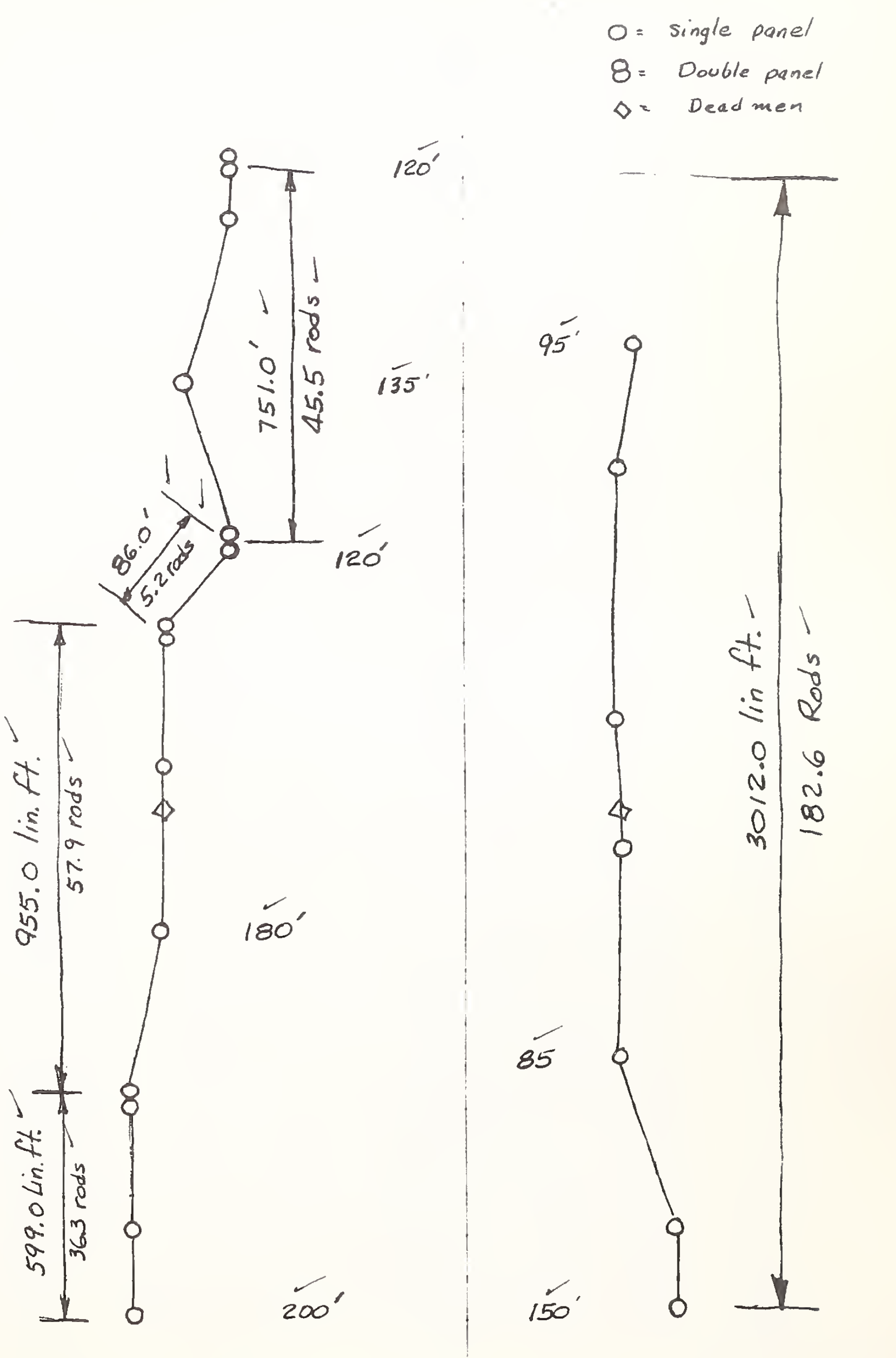
Inspection on a full time or on a part time basis will depend on the speed and location of the work underway. Some jobs have fence work underway at numerous locations and may require a full time inspector. On other jobs the inspector may need only to check the work from time to time during the day. Judgment must be exercised to determine the thoroughness and frequency of inspection required.

Records of fence construction must show what work was done each day and who inspected it. Payment is made on the basis of completed work. The number of rods of completed fence, number of gates, panels and deadmen installed and the number of hours of dozer work done. When fencing notes should reflect the quantities and location.

Samples of notes are shown in figures IV-13 and IV-13A. The left hand pages show the date of installation, item installed or used and name of the inspector. The right hand page shows the plan view, computations, conversions and personnel involved.

	PANELS		FENCE			
	DATES INSTALLED		DATES INSTALLED			
STA.	Lt.	Rt.	Lt.	Rt.	DEADMEN	DOZER HOURS
354+00	K. Keeler 10-2-69		K. Keeler 10-3-69			
352+90						4 hrs. on 10-20-69 K. Keeler
349+89	K. Keeler 10-1-69	K. Keeler 10-16-69		K. Keeler 10-20-69		
349+65						
346+64						
~~34~~						
346+40			K. Keeler 10-1-69			
345+53.6						
343+46						
342+50	K. Keeler 9-30-69				1Lt. 1Rt.	
340+22						
339+25						
336+97		K. Keeler 10-17-69				
336+00			K. Keeler 9-30-69			
332+98						
330+00						

Figure IV-13



Measured By K. Keeler
Notes By Jim Williams
By Bill Olson

Figure IV-13A

Rods Left = 181.5
Rods Rt. = 182.6
Total Rods = 364.1

IV - 69 MARKERS AND MONUMENTS

69.00 References

Standard Drawing 96-01

Standard Specifications - Section 96

69.01 General

In preparation for this item, the inspector will find it advantageous to be familiar with the given references. "Markers and Monuments" will consist of the furnishing and erection of project markers, station markers, right-of-way monuments, survey monuments, and other such markers as may be specified. These items will meet the requirements of the plans and specifications and be placed at the locations shown on the plans. The list of markers and monuments to be installed should be checked and the contractor informed of any changes before he orders his material. Markers are generally set during the latter stages of construction to prevent damage and to account for any construction changes in R/W, alignment or length of project.

69.02 Materials

Markers and monuments will be constructed of the material and in the manner required by the plans, standard drawings, and standard specifications. Generally, the material will be precast concrete posts. The fabricated posts and method of construction is usually inspected at a plant and the finished product stamped with the Ⓜ. However, the dimensions need checking along with a visual examination for observable defects.

69.03 Construction

All markers and monuments should be set in the ground at the exact plan location. If the plan location cannot be used, the engineer will have to decide on a suitable substitute location or delete the monument. A proper installation will mean the backfill material is solidly compacted using water and tamped without shifting the position of the post.

The standard drawing shows the proper placement of the post, in relation to the centerline, end of project or R/W line. Posts are set 3 feet into the ground. Project markers will be set both on the beginning and end of a project.

Station markers are generally located at every ten stations and at designated equations. The station markers are set in relation to the centerline, with the face farthest from the roadway being placed one foot inside the right-of-way line.

When required, other survey markers used may include section corners or references and elevation markers (B.M's) and monuments. Survey markers are discussed under Section 30 of this manual.

Right-of-way markers are set where the right-of-way width changes and at any other locations designated by the engineer, so the R/W line can be retraced. These posts are set with the face farthest from the roadway (the back face) coinciding with the right-of-way line.

69.04 Records

Accurate records should be kept of all materials on hand, placing details, dates of receiving material on the job and placing of items. Level data used to establish an elevation on project markers or similar markers should be recorded like other survey notes. Records of material certificates are needed.

IV - 74 Pneumatically Applied Mortar

74.00 References

Special Provisions

74.01 General

Pneumatically applied mortar is a combination of Portland Cement, water and sand that is conveyed through a hose by compressed air, and ejected at high velocities onto a surface. For easier reading the word "shotcrete" will be used interchangeably with the more technically correct name of Pneumatically Applied Mortar. The mixture is relatively dry and is capable of supporting itself without sagging or sluffing, even when it is applied on vertical or overhead surfaces. Generally it is applied in successive applications, this results in a built up surface. Manufacturers of equipment and others have used a variety of names, such as gunite, sprayed concrete, spraycrete, air blown mortar and shotcrete to describe pneumatically applied mortar.

Pneumatically applied mortar can be shot readily on surfaces that are composed of various materials, regardless of the shape or slope of the surface. It has found extensive use in the repair and strengthening of buildings, as a protective coating on structual steel, masonary, rock, concrete beams and various applications that need thin linings. Shotcrete is also quite suitable for a variety of new construction. The success of it's use is very dependent on the capability and competence of the crew doing the application work, the correct preparation of the surfaces into which it is placed, the method of placement and the capability of the particular equipment used.

Shotcrete does not contain course aggregate, therefore, much more cement is used than would be used in the same volume of concrete. This extra cement also increases the water requirement and causes the mortar to crack easier. There is no entrained air in this mortar, so it is less serviceable in comparison with air entrained concrete. This lowered durability is especially serious in areas where freezing and thawing occur in regular or frequent cycles.

The application process - two basic processes exist for applying pneumatic mortar. The dry mix process and the wet mix process.

With the dry mix process, the cement and damp sand are throughly mixed, introduced into a special mechanical feeder, metered by a feed wheel into the delivery hose and carried by compressed air through this flexible hose to the discharge nozzle. Water is introduced through a second hose entering the discharge nozzle and all ingredients are intimately mixed as the mortar is jetted out at high velocity.

In contrast, the wet mix process consists of thoroughly mixing the sand and cement with water, introducing the complete mixture into the chamber of the delivery equipment from there through the flexible hose to the discharge nozzle where additional air is injected, and the mortar is jetted from the nozzle at high velocity on the surface to be mortared.

Either the wet mix or dry mix process will produce an acceptable mortar for normal construction requirements, but there is some difference in the cost of equipment, the maintenance and operational features that may make one of the methods more attractive than the other. For instance, in the dry mix process, there is much better control over mixing water and the consistency of the mix at the nozzle. It is better suited for placing mixes that have a high percentage of light weight and porous aggregates. Also longer hose lengths can be used. With the wet mix process, mixing water is better controlled at the delivery equipment and can be more accurately measured. There is less rebound and waste because the water is usually more thoroughly mixed with the other ingredients, and less dust will accompany the spraying process.

74.02 Materials

(A) Cement

The Portland Cement used is to meet the requirements outlined in the Standard Specifications for road and bridge construction. When the type of cement is not shown on the plans or in the special provisions for the job it would be satisfactory to use Portland Cement Type II. The choice of which type of Portland Cement to use would be dependent on the physical conditions of the areas to which the mortar will be applied. For instance, where the mortar will be exposed to soil or ground water with a high concentration of soluble sulfates, Type V Cement should be used; and where structural strength is needed soon Type III high early strength Portland Cement is preferred.

(B) Sand

The sand, used in pneumatically applied mortar must meet the requirements for fine aggregate for concrete (Section M-100 of the Standard Specifications).

(C) Water

Water for mixing and curing is to meet the requirements of the Standard Specifications and be free of discoloring elements.

(D) Admixtures

Set retarders and other water reducing admixtures are usually not specified, and would require a written request from the contractor before the use of such admixtures would be permitted

Mineral admixtures such as flyash, asbestos fibers, clay or similar minerals are sometimes helpful to increase plasticity and reduce sagging, but they also increase the water requirement, increase the shrinkage and decrease strength and durability. Because of these disadvantages, the aforementioned mineral admixtures should not be used.

Admixtures that accelerate the setting of concrete will require a special request from the contractor and the field engineer, submitted through the Division Engineer to the design section, before the approval for their use can be granted.

Admixtures that have been approved for use should be dissolved in the mixing water before introduction into the mix.

74.03 Construction

(A) Equipment

Equipment for shotcrete consists of the batching and mixing equipment, delivery equipment, air supply and for the dry mix process a water supply.

Weight batching of the ingredients is preferred and strongly recommended over volume batching, no matter whether the dry mix process or wet mix process is used. If for good reason weight batching is not used, the cement may be batched by intregal bags weighing 94 pounds and the sand batched volumetrically providing that periodic weight checks are made of the sand to assure that the weights are maintained within a required tolerance. Water may be accounted for either by weight or volume batched (in the wet mix process) or introduced at the nozzle (dry mix process).

The mixing equipment used in the dry mix process should be capable of thoroughly coating the sand particles with cement and have a sufficient capacity to allow continuous placing of the mortar, the mixing time should be no less than 1 minute in a drum type mixer. The mixer should be self-cleaning and discharge all mixed material without any carry over from one batch to the next, and be inspected and thoroughly cleaned at least once a day to prevent accumulations of batch material. It is important to maintain the moisture content of sand within the limits that will allow continuous flow at a uniform rate through the delivery hose. Generally the range of 3 to 6 percent moisture in the sand is about right and the sand should be dampened or dried as required, to bring the moisture level within this range or at a value that will allow uniform flow "without slugs".

Batching and mixing equipment for the wet mix process is more equivalent to mixing for concrete batching, and the equipment should be capable of mixing the materials in a sufficient quantity to maintain continuous placing. The required mixing time will depend on the mix being used and the efficiency of the mixture, but should deliver concrete at the desired consistency and be completely uniform from batch to batch.

The delivery equipment for the dry mix process should deliver the sand cement mixture in a continuous stream of uniformily mixed material at the proper velocity to the discharge nozzle. An even distribution of water can be directed through the sand/cement mixture if the discharge nozzle is equipped with a manually operated water injection system. The water valve should be one that can be easily adjusted to change the quantity of water as needed. The stream of material discharged from the nozzle will have a cone shape and a uniform appearance throughout when all is working satisfactorily. Distortion of the stream would indicate a warn nozzle liner or other malfunction of the water injection system. The various parts of the delivery system (especially the nozzle line and water ring) should be regularly inspected and replaced as required to achieve uniform results.

The delivery equipment used in the wet mix process consists of a pressurized vessel discharging the premixed materials with the aid of compressed air. The premixed material and air pass through the hose to the gunning nozzle which is fitted with an air ring for injecting additional compressed air as needed. The wet mix delivery equipment should be capable of delivering the premixed material, accurately, uniformily and continuously through a hose that ranges in size from 1½ inches to 2½ inches. The manufacturers recommendations should be followed on the type and size of nozzle to be used, and on cleaning, inspection and maintenance of equipment. If vertical or overhead work is to be done the equipment should be tested to be sure that it will have proper capabilities.

The air supply used for a dry mix or a wet mix process must be furnished through an air compressor that can maintain sufficient nozzle velocity for all parts of the work, and at the same time provide pressure for operation of a blow pipe to clear away rebound.

(B) Preparation of Surface to Receive Mortar

Such earth surfaces as those exposed in canal linings, roadside ditches, backslopes, etc., should be kept damp for several hours before applying the shotcrete. Do not apply mortar on any surface that is frozen, spongy or containing free water.

Shotcrete can be used to repair deteriorated concrete if all of the unsound material is first chipped off and the area sand blasted to clean the concrete and exposed steel. Square shoulders should not be left at the edges of the cavity. All edges should be rounded and/or tapered. Unsound or improper preparatory work is usually the culprit responsible for more failures than any other single factor in repair work. Concrete surfaces that are to receive shotcrete should be thoroughly cleaned followed by wetting and damp drying. The nozzleman can usually scour the area clean ahead of the application by using an air-water jet. Free water from this cleaning can be blown away by compressed air. Surfaces that are sound but porous should be kept damp for several hours before applying mortar.

Surfaces composed of solid rock should receive an air-water treatment to clean cracks and remove loose rocks.

(C) Applying Mortar

Mortar is sprayed on the area by holding the nozzle between two (2) and five (5) feet from the work, and building up each layer of the mortar by making several passes with the nozzle over the working area. The nozzle is usually held perpendicualr to the surface, exept when an encasement of reinforcing bars is to be sprayed. For reinforcing bars, the nozzle should be held a little closer and at a slight angle from the perpendicular to permit better coverage and help in the removal of rebound.

The thickness of each layer being placed is governed in general by how much can be placed without sagging. When placing mortar on walls, the application should begin at the bottom. The first layer placed should at least completely imbed the reinforcement that is adjacent to the form.

When coatings of one (1) inch or more of thickness are to be applied to vertical or nearly vertical surfaces two (2) or more layers should be used. Each layer being no more than three-fourths (3/4) of an inch in thickness. Thicker layers might sag or slough. Level or slightly sloping surfaces can tolerate a single layer varying in thickness from one (1) inch to a maximum of about three and one-half (3½) inches.

As the placed mortar begins to cure and set, a glaze coating appears which is a deterrent to a good bond. When more than one (1) layer is applied, a delay of approximately 30 minutes to an hour between applications is usually sufficient to prevent sloughing, yet not so long as to allow a glaze to form.

A crew of usually three (3) men, a nozzleman, machine operator and a man to clear away the rebound are used to apply mortar. These men should be experienced and know how to make adjustments, because the quality of the finished work depends to a very large extent on the skill of the men who place it. Each member of the crew must know enough about the other men's work to be able to anticipate actions, corrective measures that should be taken, and aid each other in a team effort. For instance, the machine operator will regulate the air and water pressure, and the rate of feed of the material to produce a uniform flow at the nozzle at a proper velocity. The nozzleman can then correct the amount of water.

(D) Forms

Where forms are required, they should be made of plywood sheeting or other suitable material, positioned true to line and grade and adequately braced to insure protection against excessive vibration. Forms should be constructed to permit the escape of air and rebound during the placing operation, especially in the case of thick structural members. When forms are used they should be oiled or dampened and thoroughly cleaned just prior to their use.

(E) Reinforcement

Reinforcing steel will be used on many of the jobs requiring mortar. The reinforcement may consist of round bars strategically placed or a welded wire mesh. In either case sufficient clearance must be provided around the reinforcement to permit complete encasement with sound mortar. The usual minimum clearance between the wire mesh reinforcement and the surface to be mortared is approximately one-half (½) inch and up to two (2) inches clearance is used for a concrete mix with number five (5) reinforcing bars. Wire mesh should be positioned so that the mortar can be sprayed or shot in at a slight angle from opposite sides if needed. All reinforcement should be clean and free from loose mill scale, loose rust or similar coatings that might interfere with bonding of the mortar. Reinforcement bars should be separated by at least two (2) inches wherever possible. Wire mesh that must be spliced should be lapped at least one and one-half (1½) squares in all directions.

(F) Alignment

Control of alignment and grade must be accurate to establish the thickness and surface planes when constructing corners of walls, columns, beams and similar work. Precise control of horizontal or vertical alignment would not ordinarily be required for such mortar work as lining highway ditches, backslopes, rock embankments or placement under bridges.

Although the latter type of work does need control of alignment and grade, an 18 or 20 guage hard steel piano wire is recommended for use as an alignment device. These wires should be streched tight and made true to line and placed in such a manner that they may be tightened when they become loose.

(G) Rebound

Rebound is mortar particles that bounce off surfaces it is sprayed against. As the thickness of the mortar layer builds up, rebound should decrease because there is more of a plastic cushion for the mortar to strike. The nozzleman can make adjustments for the amount of water that will be at the nozzle and apply the mortar systematically so that rebound can be kept to a minimum and be cleared away from his work.

The reboundman, knowing the action of the nozzleman, can adjust his activities to clear rebound from areas that the nozzleman has made ready. He can systematically cover areas that have already been cleared of rebound.

Wind will blow spray from the nozzle, and prevent good control or consistency of pneumatically applied mortar, therefore, operations should be suspended when wind conditions exist.

74.04 Finishing and Curing

The natural finish left by the shotcrete operation is usually preferrable, both for strength and durability. Further finishing should be avoided because it might disturb the bond between the mortar and reinforcement or underlying material, it might create cracks in the mortar. Where the natural finish is unacceptable because of it's roughness, special finishes might be applied. A smooth finish can be made by brooming after the mortar has taken it's initial set. A much finer finish with better appearance can be made by applying a thin surface coating containing finer sand than normal and making the application with the nozzle held well back from the work. This type of finish should be applied as soon as possible.

Fresh work is to be protected from loss of curing water by application of a curing seal or covering with straw or damp sand a few inches thick. Curing should continue for at least seven (7) days.

74.05 Inspection and Testing

Testing for strength may not be a requirement but if it is, the following suggestions are offered for your use.

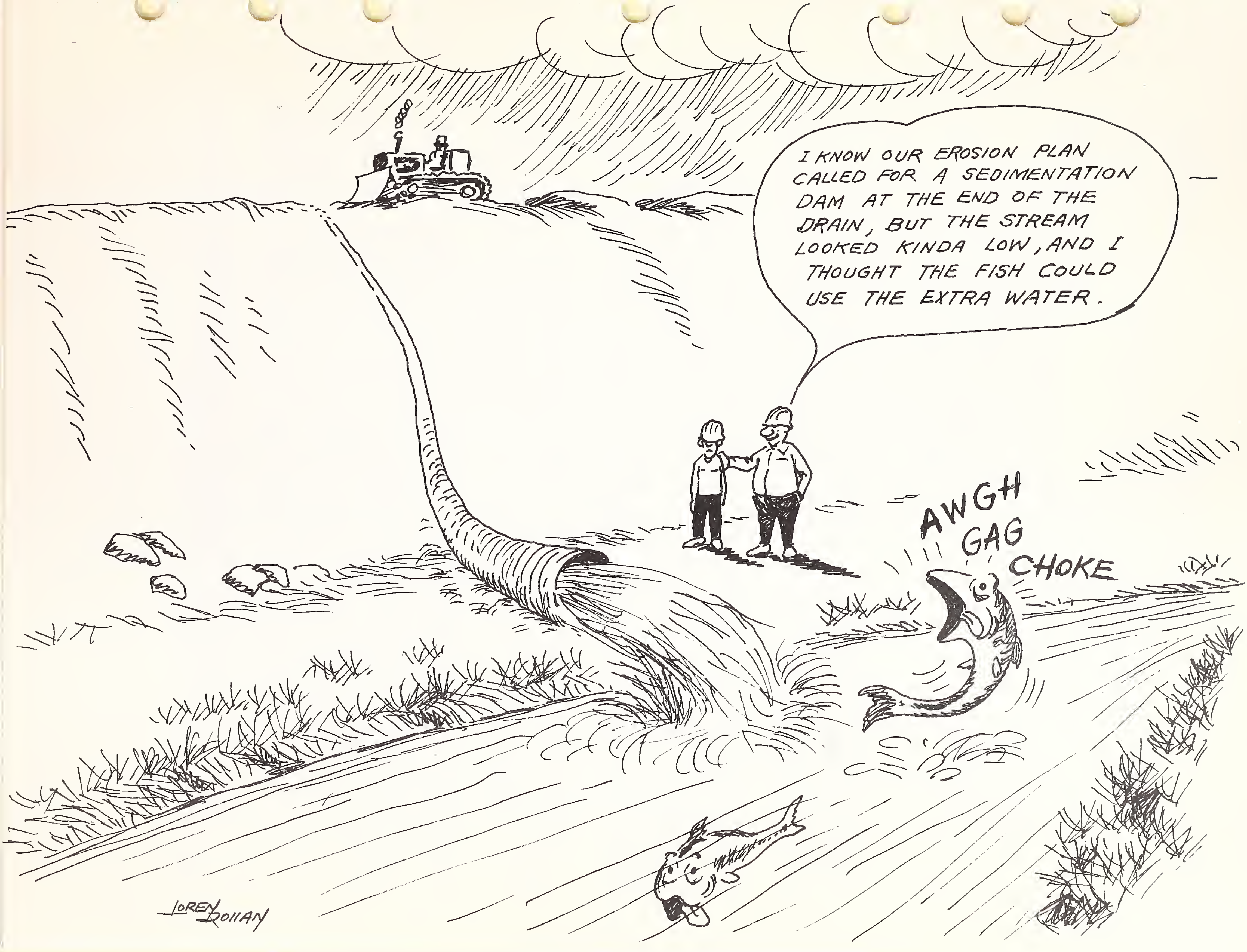
Testing should be conducted in the field to determine the mix proportions, gradation and quality of the aggregate, the correct quantity and spacing of wire mesh, or reinforcing steel if used, the design condition capabilities of delivery equipment, and especially the quality of workmanship.

A 6 x 12 inch cylinder can be made by gunning the mixture into a mold constructed of hardware cloth, but since specimens made in this manner may not be representative of the mortar placed into the structure, especially the vertical and overhead applications, these tests are not considered reliable. More reliable test information is gained if a panel is fabricated from plywood which contains the same reinforcement as the structure. Such a panel should be large enough to indicate the quality that might be expected in the structure and should be capable of containing all of the test specimens needed. The minimum size of the panel should be no less than 30 inches square. The thickness of mortar placed on the plywood panel should be the same as that in the structure except that it should not normally be less than three (3) inches. Each mix design used will require a separate panel, and each panel used should be placed in the same position as that position encountered in the work "flat, vertical, overhead, sloping".

The test panels can then be cored, or cubes can be taken from them for testing. Cores should have a minimum diameter of three (3) inches and an $\frac{L}{D}$ ratio of at least one (1) if possible. Specimens should be tested in compression at seven (7) days and twenty-eight (28) days or both and the core strength corrected for the $\frac{L}{D}$ ratio as described in ASTM C/42 "obtaining and testing drilled cores and sawed beams of concrete". Cube strengths may be reported as determined or they may be converted to cylinder strengths, by multiplying with a factor of 0.85.

The cut surfaces of specimens must be carefully examined and additional surfaces exposed by sawing or breaking the panel. This is considered necessary to check for the soundness and uniformity of the sprayed mortar. All cut or broken surfaces should be dense, free from laminations and free from sand pockets.

Other tests for absorption, drying, shrinkage, resistance from freezing and thawing or other properties may be made if required. by using the appropriate cored or sawed specimens from the panel.


I KNOW OUR EROSION PLAN CALLED FOR A SEDIMENTATION DAM AT THE END OF THE DRAIN, BUT THE STREAM LOOKED KINDA LOW, AND I THOUGHT THE FISH COULD USE THE EXTRA WATER.
AWGH GAG CHOKE
LOREN DOLLAN

IV-75 TEMPORARY EROSION & SEDIMENTATION CONTROL

75.00 References

Standard Specifications: Section 17

Standard Drawings:

Field & Office Standards: Standard Sheets 58 through 69

Construction Manual: IV-44

75.01 General

Temporary erosion and siltation control measures are a growing concern of Project Managers throughout the State. Temporary measures, of their very nature, must give immediate protection, be easily and inexpensively applied, and they must perform adequately, with minimal maintenance, until permanent erosion control is established.

The contractor is required to submit a temporary erosion control plan prior to beginning construction. The engineer should not accept a plan which, in essence, says only that the contractor will do whatever the engineer directs him to do. The engineer should cooperate with the contractor in compiling a DEFINITIVE PLAN, which may include a clause stating that the contractor will do additional work as deemed necessary by the engineer. An example of a good erosion and sedimentation control plan is included as Appendix 75-C.

Some particular areas, where excessive erosion and siltation frequently occur, are newly exposed cut and fill slopes, moderate and steep graded unlined ditches, cut to fill transitions, and any newly constructed drainage areas, i.e., equipment and storage yards.

When work is required to be done in a stream, i.e. bridges, channel changes, etc., or when construction equipment is required to cross a stream, the quality of water in the stream should be preserved. The State of Montana, Department of Health should be contacted by the contractor for guidance as to allowable turbidity and sedimentation limits that have been placed on the stream. Allowable limits will depend on the stream's "water use classification" but a general rule that will keep you out of trouble is to keep the stream as clear as it is in its natural state. All construction equipment should be kept out of the stream except when it is absolutely necessary that they enter the stream to do the work.

The engineer should contact all the Federal, State, County, and Municipal Agencies that may be concerned with erosion problems created by the construction. Every effort should be made to cooperate

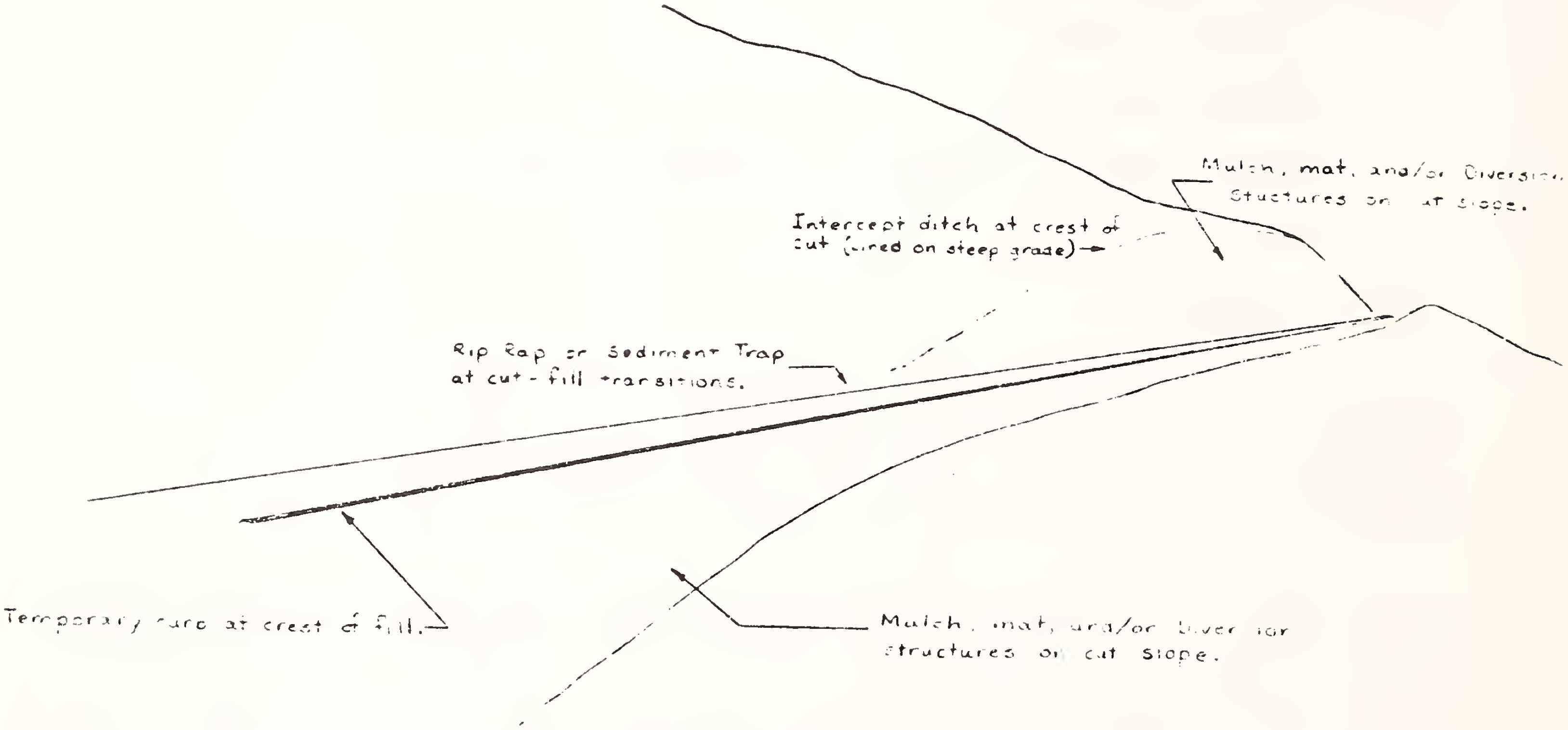

Mulch, mat, and/or Diversion Stuctures on cut slope.
Intercept ditch at crest of cut (lined on steep grade)
Rip Rap or Sediment Trap at cut-fill transitions.
Temporary curb at crest of fill.
Mulch, mat, and/or Diver ion structures on cut slope.

Figure 75-1: Typical utilization of temporary erosion and sedimentation control features.

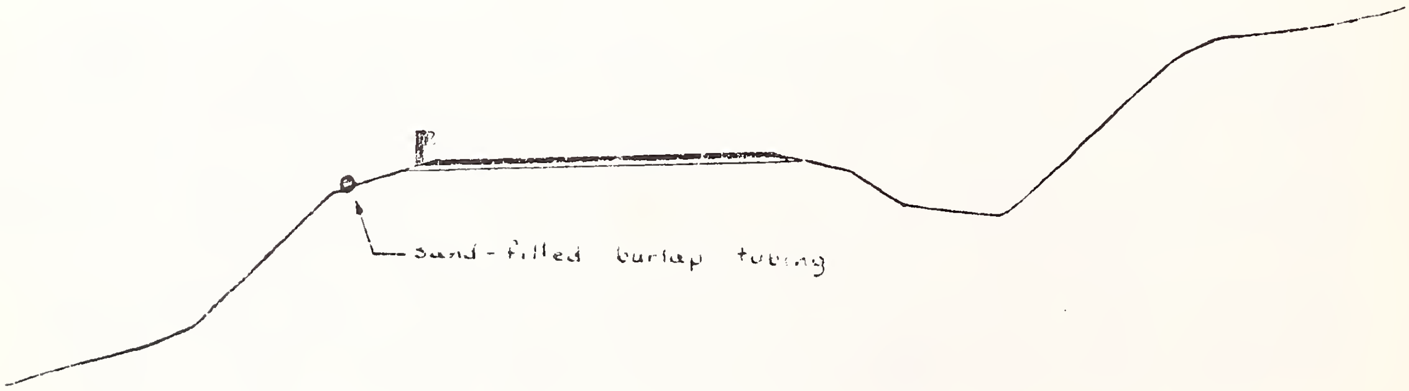


Figure 75-2: Temporary curbing, sand filled burlap tubing can be left in place to disintegrate or it may be removed when permanent erosion control is established.

with these agencies so that temporary control measures will be adequate to meet their requirements. Some State and Federal Agencies that should be contacted are listed below:

STATE AGENCIES

Department of Fish and Game
Department of Natural Resources and Conservation
Department of Health and Environmental Sciences
Department of State Lands

FEDERAL AGENCIES

U.S. Geological Survey
U.S. Bureau of Land Management
U.S. Forest Service
U.S. Bureau of Mines
U.S. Bureau of Indian Affairs
Soil Conservation Service, U.S. Department of Agriculture
Other appropriate Federal Agencies

There is probably little agreement on the meaning of "adequate" erosion control. Temporary measures used during construction activities do not prevent all sedimentation processes from occurring, they only control them. As the energy responsible for sedimentation processes is provided by falling and flowing water, it is essential that control measures effectively eliminate, divert, or dissipate this energy. Exposed soils must be protected from the impact of rainfall. Runoff must be diverted from erodible areas and its velocity reduced. Sediments being transported by water should be trapped in sediment basins located in the construction site area.

This section is intended to give ideas on methods of temporary erosion and sediment control. Some of the methods in the following text may be mentioned as being good solutions to given situations. This should not be interpreted as inferring that they are the only solutions, the best solutions, or that they are even solutions to the same situations under different circumstances. On the other hand, a given method is very likely to be applicable to any number of other situations for which another solution may or may not have been mentioned. For example: a temporary curbing can be used on the crest of a cut slope or an intercept ditch may be cut at the crest of a fill.

Appendix 75-B Erosion Control Practice, is added as a tabulated reference on accepted erosion and sedimentation control practices, with their advantages and disadvantages.

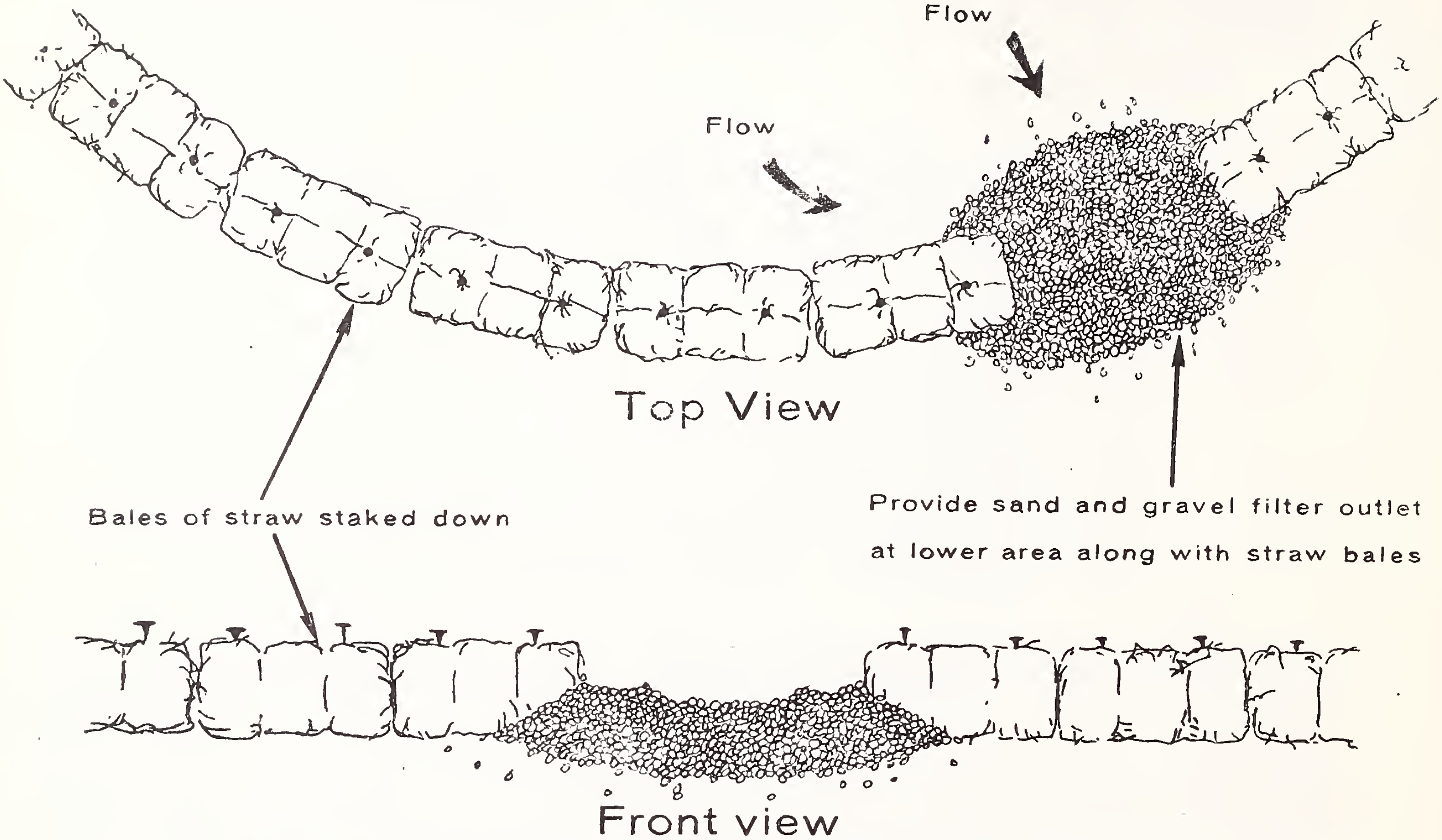

Flow
Flow
Top View
Bales of straw staked down
Provide sand and gravel filter outlet at lower area along with straw bales
Front view

Fig 75-3: Semi-pervious barrier of hay bales with more pervious embankment of sand and gravel for spillway.

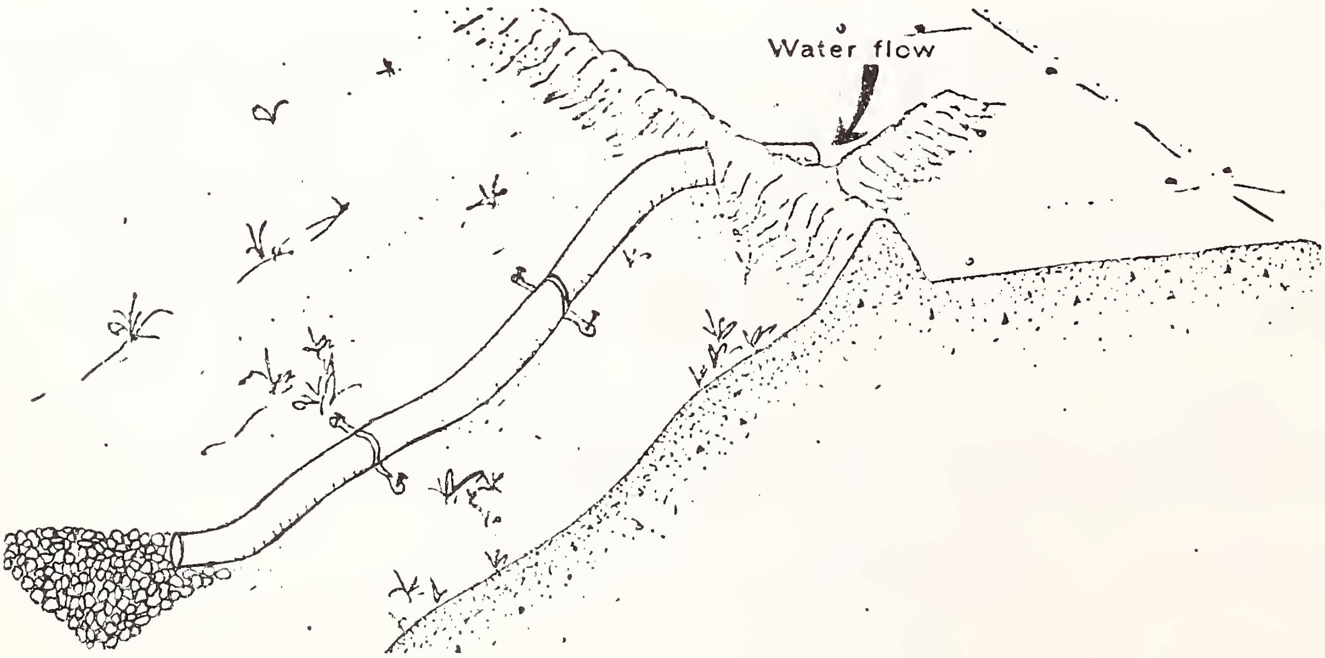


Fig 75-4: Temporary compacted earth curing with temporary, flexible slope drain. Discharges on gravel energy dissipator to prevent erosion at discharge end.

75.02 Surface Protection of Exposed Soils

Vegetation and mechanical control measures should be used concurrently. (Figure 75-1) Areas requiring surface protection include any bare erodible soils, but particular emphasis should be placed upon protecting long, steep slopes and areas where runoff water can concentrate.

All slopes of 2:1 and steeper should be mulched to protect them from precipitation as soon as they are shaped.

Mulches are usually applied in conjunction with seeding operations. However, it is conceivable that a slope may need protection before and until it can be seeded. In this case a sterile mulch, or a mat or mesh, may be used simply as a temporary erosion control measure but may have to be removed before seeding the slope.

A. Mulches

Spreading material on slopes with either a pneumatic mulcher or a hydroseeder or hand broadcasting is common practice in establishing grass on roadway cuts or fills or other newly disturbed areas. The addition of a mulch is expensive and is not always necessary to establish grass stands on favorable sites. Mulch is particularly important, however, in obtaining a satisfactory stand of grass on harsh sites. Mulches are an erosion and siltation preventive measure as well as a measure to conserve moisture for seedling establishment There are several commonly used mulches that will adequately protect exposed slopes from the erosive effects of the wind and falling rain.

1. Wood Fiber

Wood fiber at 1,500 pounds per acre gives consistently favorable results under all conditions except in areas where frost heaving or excessive surface water flow exists. If wood fiber is applied at rates less than 1,000 pounds per acre or on steep unstable slopes, little benefit may be obtained.

2. Straw-Asphalt

Straw at 1½ tons per acre, bound with asphalt at 300 gallons per acre, gives beneficial results with respect to establishment of seedlings but this mulch is susceptible to being carried away by wind and water. Straw is often contaminated with grain and weed seed that can produce fatal competition with newly planted grass seedlings. Straw-asphalt mulch establishes better stands than wood fiber where winter and early spring-frost heaving is a serious problem.

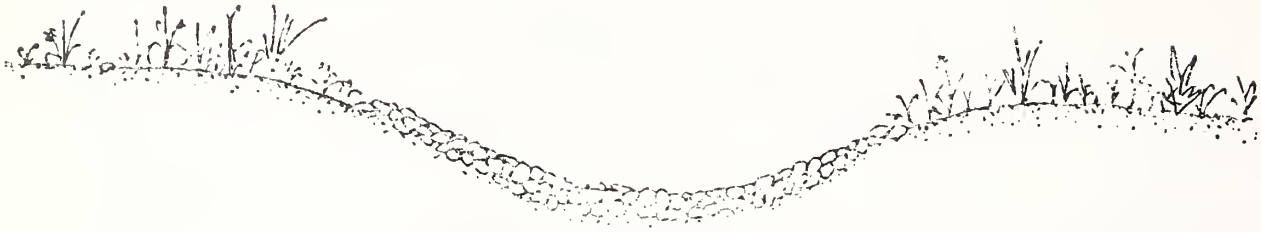


Fig. 75 -5: Diverson channel lined with gravel to prevent erosion.

3. Macerated Paper

Macerated paper is produced by passing newspaper through a hammer mill operating at a moderate speed with a 10-mm screen opening. When applied as a slurry at 1,500 pounds per acre, it gives satisfactory results but it is not as long lasting as wood fiber or straw-asphalt mulches.

4. Soil-Anchored Mulch

Either straw or hay can be distributed uniformily over the soil surface and held in place by punching it into the surface soil with either a mulch tiller, a modified sheepsfoot roller, or a weighted agriculatural type disk. The foregoing mulch anchoring methods adequately cover the seed; therefore, it is not necessary to cover it with soil prior to adding mulch.

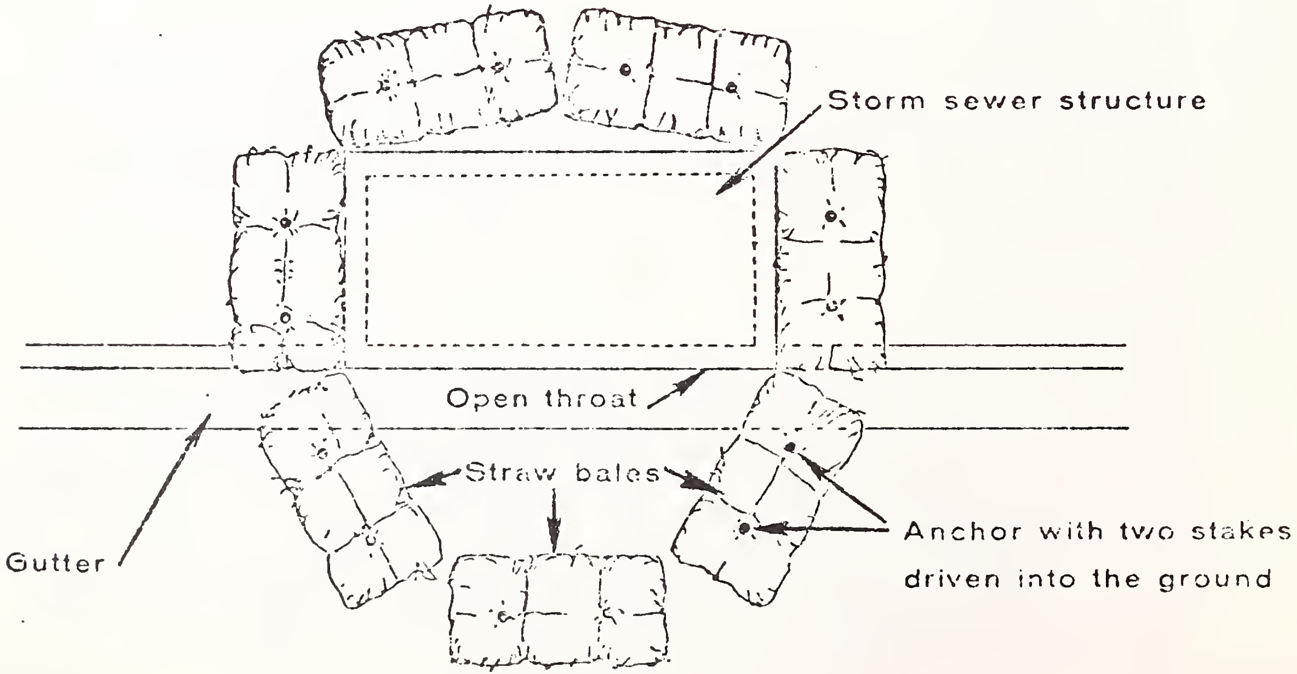


Fig. 75-6: Temporary barriers of hay bales to prevent sediment-laden water from entering incomplete storm sewer system.

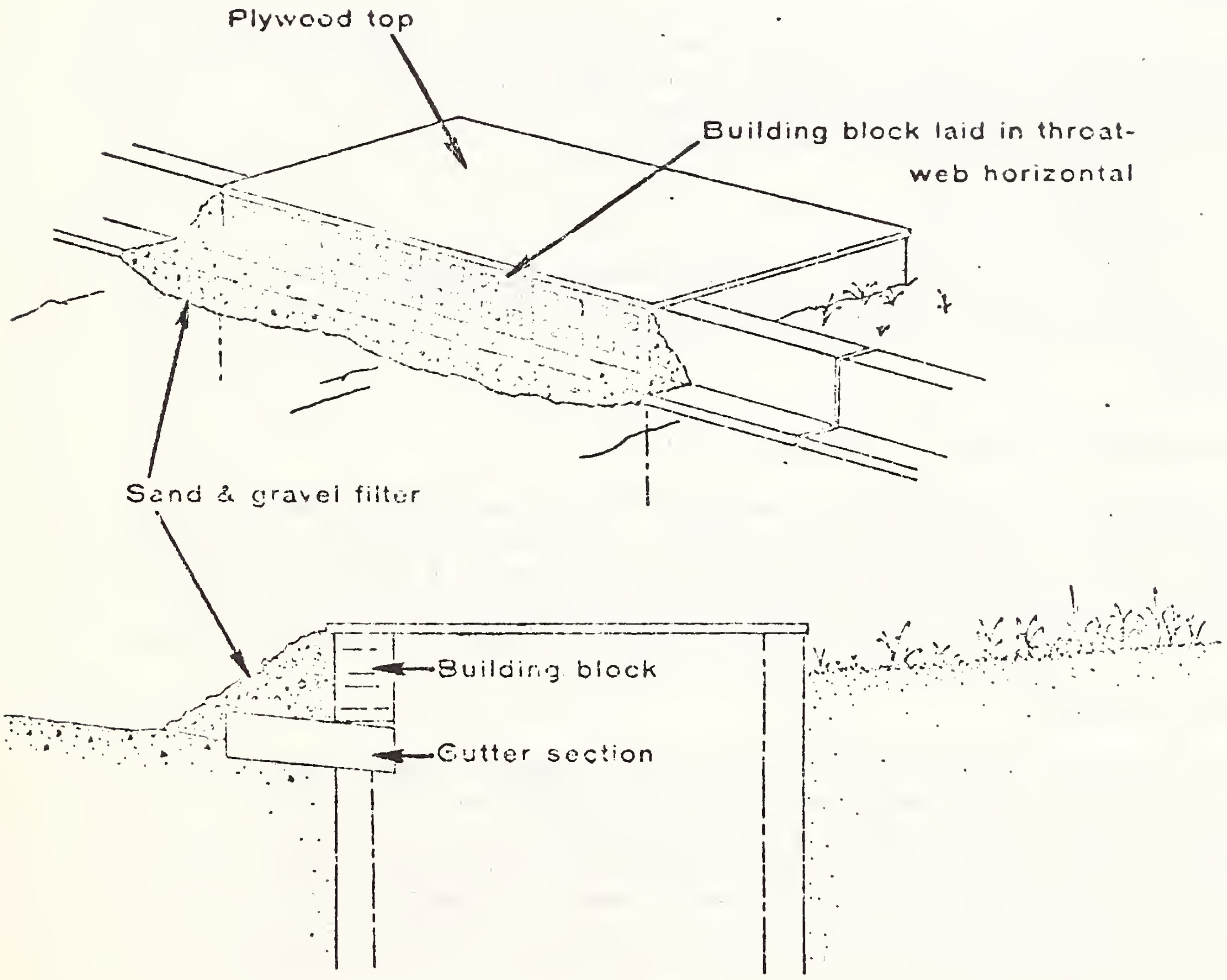


Fig. 75-7: Sand and gravel filter protecting intake area of incomplete storm sewer system.

5. Gravel

Where desert conditions or wind erosion prevail and where establishment of vegetation is almost impossible gravel mulch, with aggregate diameters ranging from .75 inch to 2.0 inches, applied to a depth of 2 inches effectively modifies soil surface temperature extremes, conserves moisture, restricts surface erosion and promotes consistent stands of grass comparable to those established with wood fiber.

6. Asphalt Film

Asphalt applied directly to roadside slopes without straw IS NOT effective as a mulch. In some cases, it is believed the solar heat asbsorbed by the asphalt is lethal to the fragile grass seedings.

B. Mats and Mesh Covers

Some areas are subject to severe wind or water erosion and must be securely protected prior to plant establishment. Such protection can best be brought about by the use of mats or mesh covers.

1. Jute Mesh(Burlap or Cheese Cloth)

Jute mesh is effective in establishing seedlings but is expensive and laborious to apply. If not properly applied, water will run beneath the mesh and create gullies. Jute mesh is, however, long lasting and may be justified on unstable sloping sandy soils or on critical drainage areas.

2. Excelsior Mat

A continuous covering of excelsior, applied as a mat, is as effective for temperature modification, moisture conservation and seedling establishment as straw and asphalt mulch with the added benefit that it is not contaminated with grain and weed seed. However, the mulch is expensive, laborious to apply, decomposes rather rapidly, and may attract mice which feed on the grass and shrub seedlings during the winter.

3. Fiberglass Roving

Random application of fiberglass filaments tacked with asphalt cement effectively prevents erosion of ditches prior to establishing permanent vegetation. After the area is fertilized and seeded, it is lined with two layers of fiberglass roving and AC-8 asphalt cement. Each layer consists of fiberglass roving at 0.25 lb. per square yard and asphalt cement at 0.25 gallons per square yard.

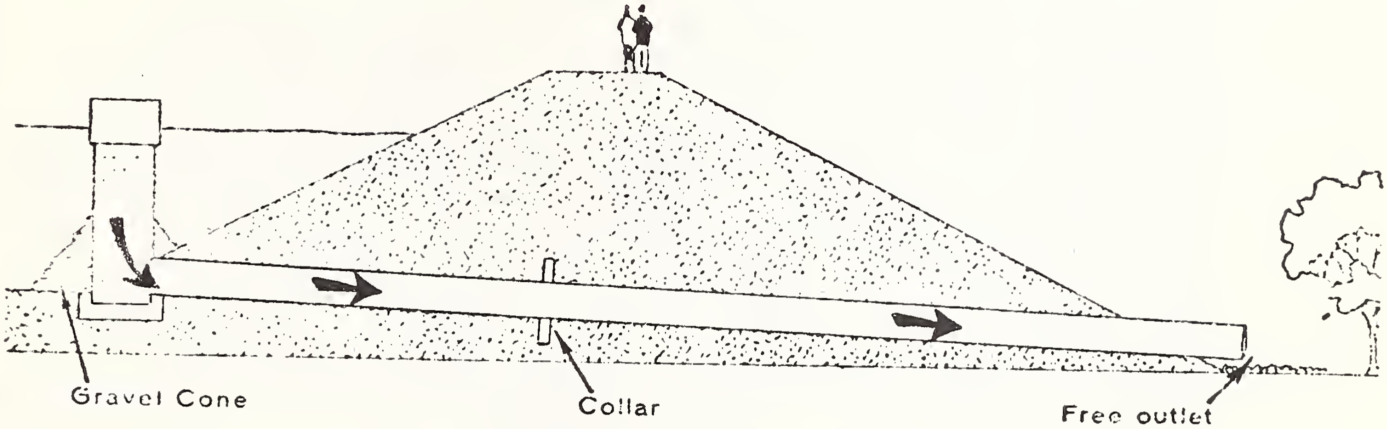


Fig. 75-8: Large, well-engineered sediment basin dam. Note outlet pipe with riser, gravel cone filter, and seepage-path cut-off collars on outlet.

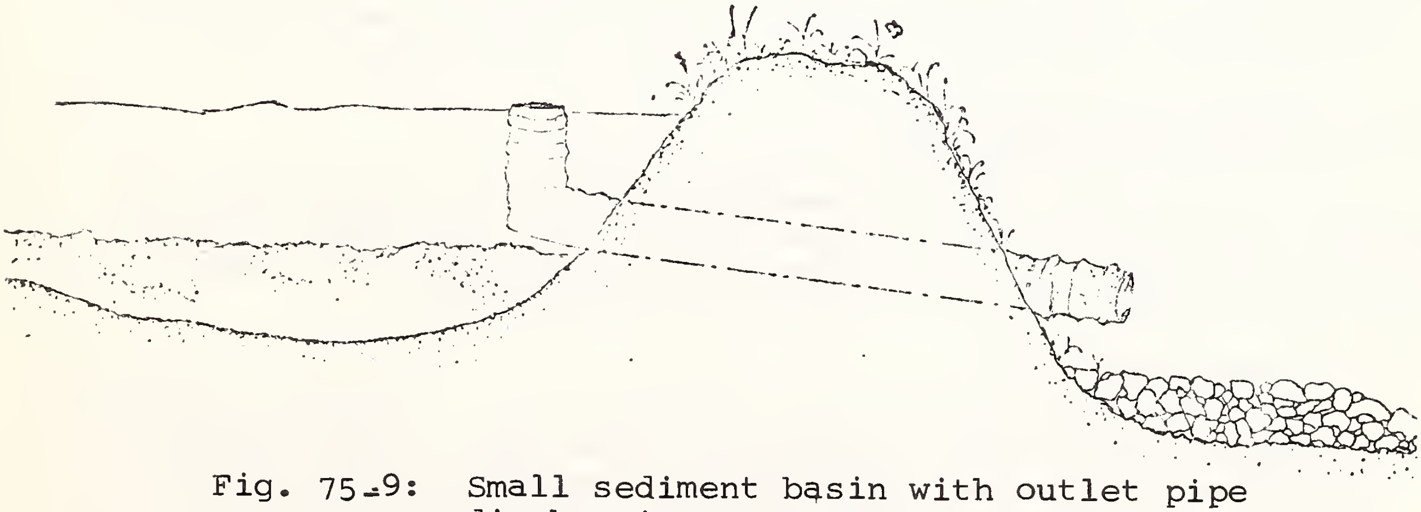


Fig. 75-9: Small sediment basin with outlet pipe discharging on energy dissipator to prevent erosion at discharge end.

4. Plastic Sheeting

Plastic sheeting is commonly used in the construction of structures to protect work or workmen from the weather. This same sheeting may be used to protect exposed slopes from the eroding effects of wind and rain. Plastic sheeting is not an effective mulch with respect to seedling establishment because it prevents moisture from entering the ground surface and seedlings can't penetrate it from beneath. Its advantages as slope protection are that it comes in large sections and, if it is properly anchored, it can virtually eliminate the erosive effects of rain and wind. Its main disadvantage is that is must be properly anchored and keyed into the surface to eliminate water and wind from getting under it. If the sheeting isn't properly keyed water can flow under it causing as much erosion as if it weren't there. If it isn't properly anchored water or wind can wash or blow if off the slope.

C. Sodding

Sodding is an effective method of controling erosion in moderate graded ditches and steep slopes. It is the only way that permanent vegetative erosion control can be installed and be effective immediately, eliminating the need for any other temporary erosion and sedimentation control devices. However, sodding is expensive. Its use is relatively rare because it is frequently not readily available and because seeding and mulching can usually produce the same results for less money. Sodding will generally not be used unless it is called for on the plans. When it is called for, installation requirements will be outlined in the Standard Specifications and Special Provisions.

75.03 Control of Runoff Water

Control of runoff can be accomplished by the installation of temporary diversions, berms, slope drains, flow barriers, or other types of structures which will prevent concentration of runoff, in areas of erodible soils, or decrease its velocity.

A. Runoff Diversion

The first requirement in stabilizing cut and fill slopes is to prevent runoff from flowing over the face of the slopes. Diversion structures, consisting of temporary compacted earth embankment, bales of straw, ditches, and furrows that can quickly be constructed, can be used to intercept runoff before it reaches erodible areas. They decrease the velocity of the runoff and channel the water toward erosion-resistant natural or artificial drainage ways that can carry it out of the construction site. Particularly critical areas for the

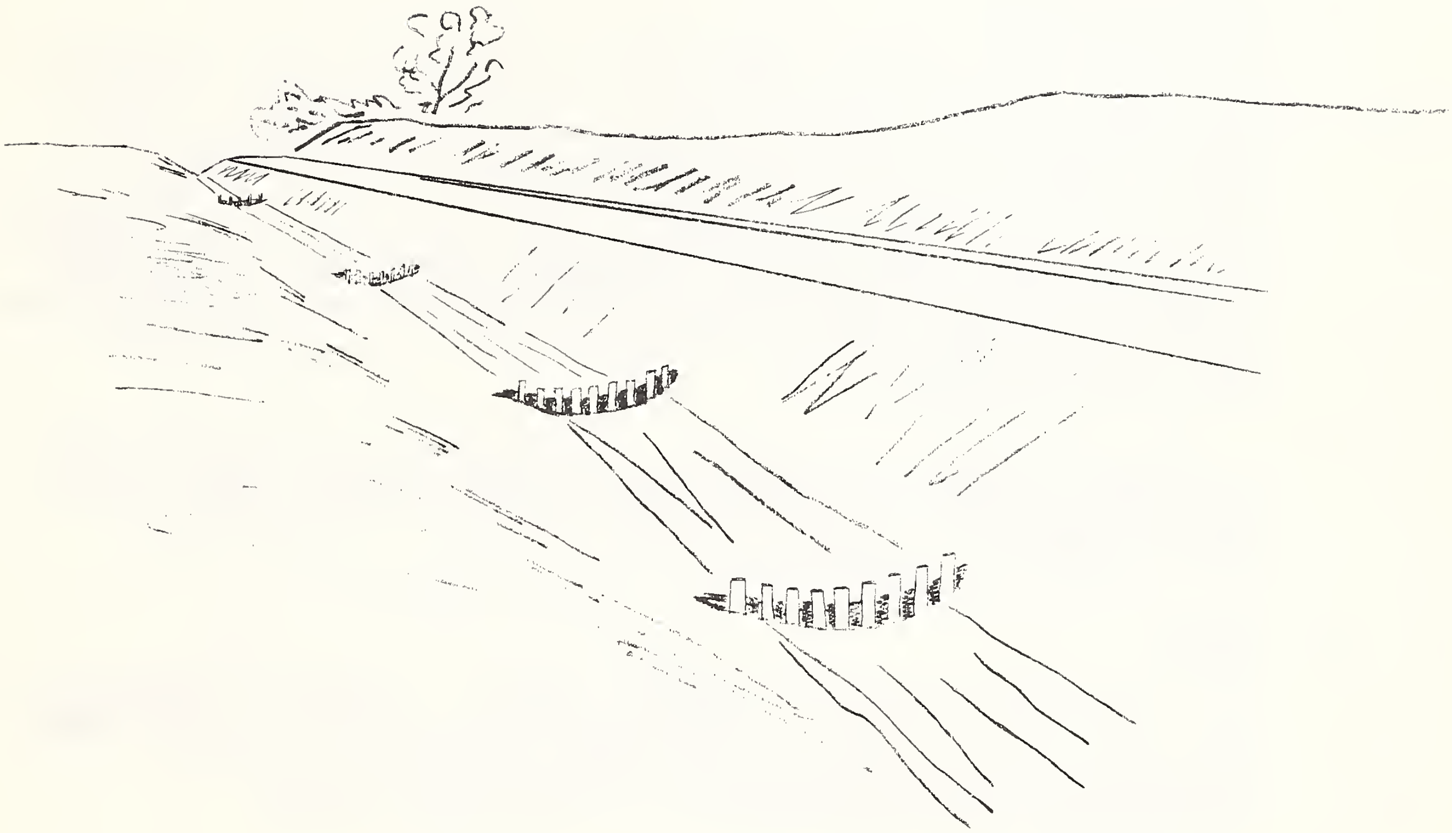


Fig. 75-10: Temporary semi-pervious flow barriers. Straw or brush and wire fencing placed behind stakes to decrease velocity of water and trap sediments.

installation of diversions are at the crests of cut and fill slopes where they can prevent runoff from gaining access to the slope. (Figures 75-1 thru 75-5)

1. Temporary Curb

Temporary curb may be constructed of any material available that will divert runoff from the erodible slope. It may be necessary to install a temporary curb to direct runoff coming from the relatively flat surface of an equipment yard, borrow area, or incomplete cut or fill, into a sediment trap. The use of compacted earth and straw bales is illustrated here. Other materials that may be used are timber or planks laid on edge and embedded into the subgrade, sand-filled burlap tubing (Figure 75-2), and any other available material.

A copy of a report by the Utah Department of Highways and the cover letter for this report on the use of sand-filled burlap tubing as temporary curbing are of interest and are attached as Appendix 75-A.

2. Berms

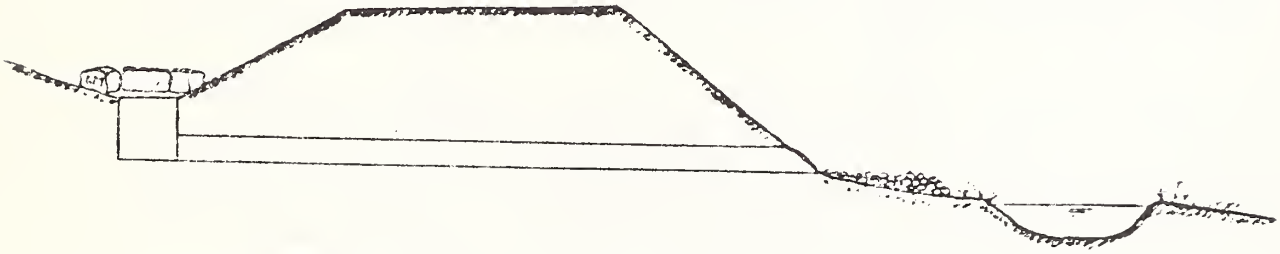
Berms or broad benches, sloping inward, placed at contour intervals on a slope will decrease the length of the slope and divert runoff into slope drains where it can be discharged into nonerodible, or protected areas.

B. Slope Drains

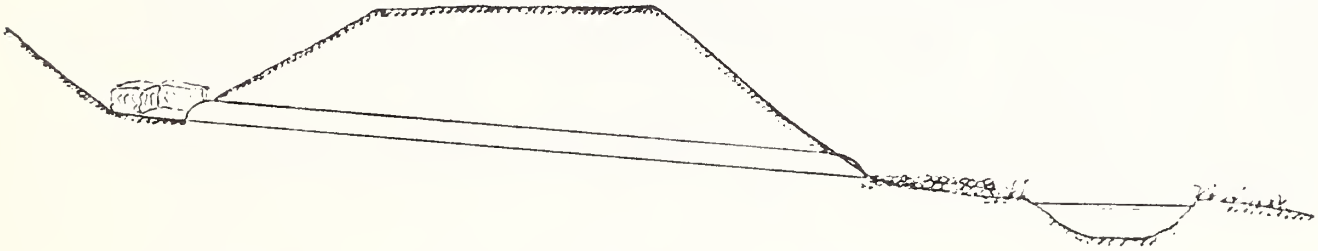
Slope drains often are used to carry water from diversion structures and the upper part of slopes to topographically lower areas or into channels where the energy can be dissipated. Very portable and light weight flexible neoprene tubes are reported to be excellent for temporary use as they can be installed quickly and by two men. (Figure 75-4) Because of their light weight, flaps with grommets are attached so that the tubes can be anchored to the slopes with stakes. Being flexible they can easily be curved and fitted with extensions to enable them to discharge into erosion resistant areas.

Other kinds of tubing, pipe, or lined slope drain channels may also be used. But in all cases the effectiveness of slope drains should not be cancelled by permitting the discharge from them to cause erosion. In many areas, energy dissipating structures or sediment traps may be required to complement the operation of a drain or other structure.

(A) Straw bale barrier around drop inlet.



(B) Straw bale barrier around standard inlet.



(C) Temporary riser to form sediment basin.

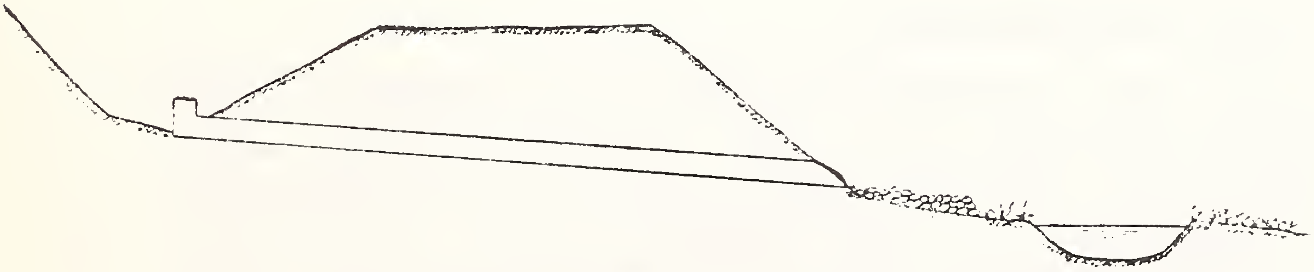


Fig. 75- 11: Temporary sediment trap on upstream end of culvert where sedimentation may gain access to stream through culvert installation. (Raising inlet may be all that is necessary to form a sediment trap.)

75.04 Trapping of Sediments (Figures 75-6 thru 75-14)

Sediments carried by flowing water can be trapped behind small temporary barriers or in large sediment basins or reservoirs which decrease the velocity of flow below that necessary for sediment transportation. Barriers used may be impervious enough to stop completely the flow of water or may consist of semi-pervious materials such as sand, gravel, brush, or even bales of hay. In the latter cases, the barriers also act as a filter which allows the movement of water but retains most of the sediment load.

The size and cost of structures to trap sediments probably vary more widely than any others used for sediment control purposes. Barriers range from small temporary dikes several feet in height, constructed of bales of hay or quickly compacted soils, to large well-designed earth dams which are engineered to specified requirements. Large impervious barriers for sediment basins generally are constructed with uncontrolled outlet pipes extending under, or through them. After the water has deposited its sediment load in the reservoir it can escape through the riser pipe which extends above the sediment storage level. Very large barriers and sediment basins are used where rainfall is seasonal and construction is detained for long periods of time. Semi-pervious barriers may consist of a dike, formed by bales of hay staked to the ground, and a low spillway-embankment section of sand and gravel that permits slow movement of water through it. (Figure 75-3) These types of barriers generally are small and quickly constructed in areas where rainfall is more uniform and storm periods fairly short.

When temporary sediment basins are no longer needed and must be removed, removal should be done only after all accumulated sediment has been cleaned from the basin. The berm or dike that forms the basin must be removed in such a manner that the removal operation itself is not a source of sedimentation.

75.05 Records & Documentation

An attempt will be made to include all foreseeable temporary erosion control features on the plans. In this way they can be treated as any other bid item in the contract agreement. Many, perhaps most, of the measures needed will not be anticipated and will have to be worked on a force account basis. At any rate, complete records should be kept, in the diary and notes, of all material and equipment hours needed to complete the work. The location and nature of the work should also be documented. The dates for staking and installation, and the signatures of inspectors are a necessary part of good notekeeping. Force account records should also be kept on maintenance and removal of all temporary erosion and sedimentation control devices.

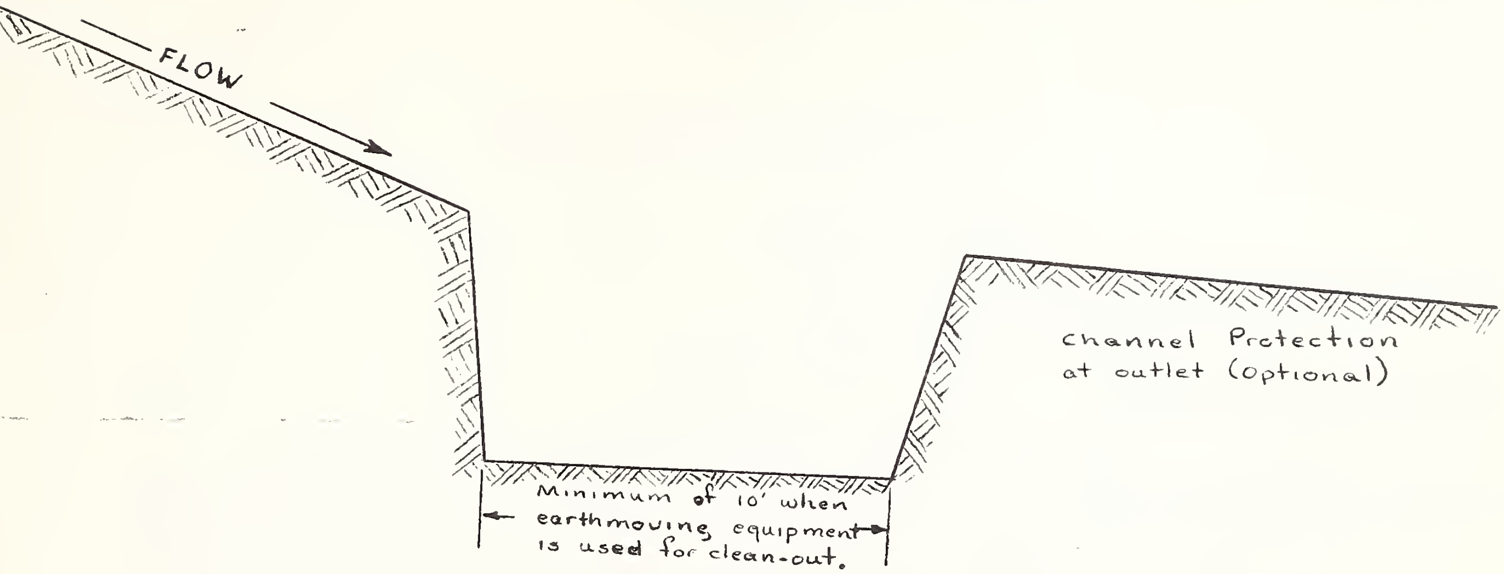

FLOW
Channel Protection at outlet (Optional)
Minimum of 10' when earthmoving equipment is used for clean-out.

Figure 75-12: Sediment Trap - Pit type, may be constructed at the toe of exposed slopes or in ditches. When used to support a sediment barrier this type of sediment trap should be constructed upstream from and before the sediment barrier.

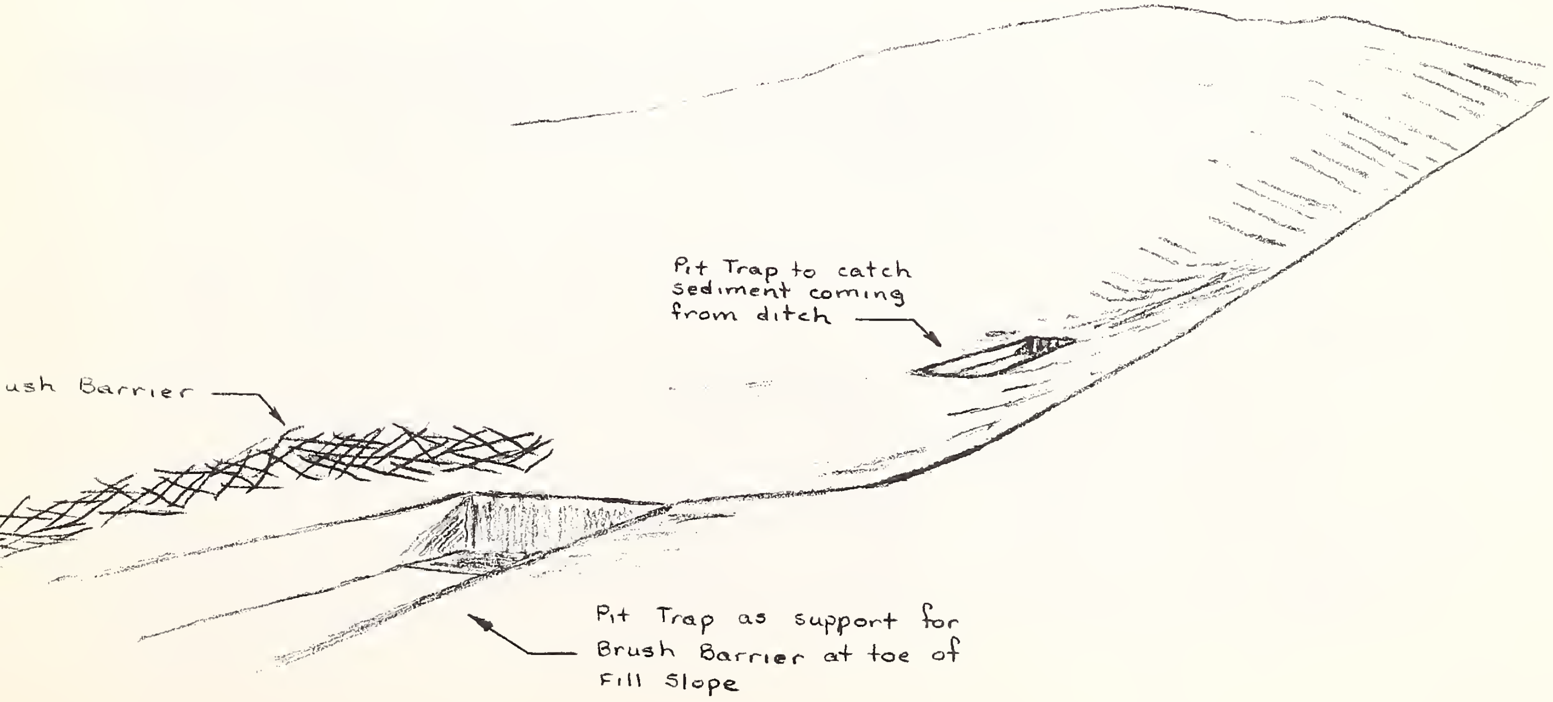

Pit Trap to catch sediment coming from ditch
ush Barrier
Pit Trap as support for Brush Barrier at toe of Fill Slope

Figure 75-13: Possible uses of Pit Type sediment trap.

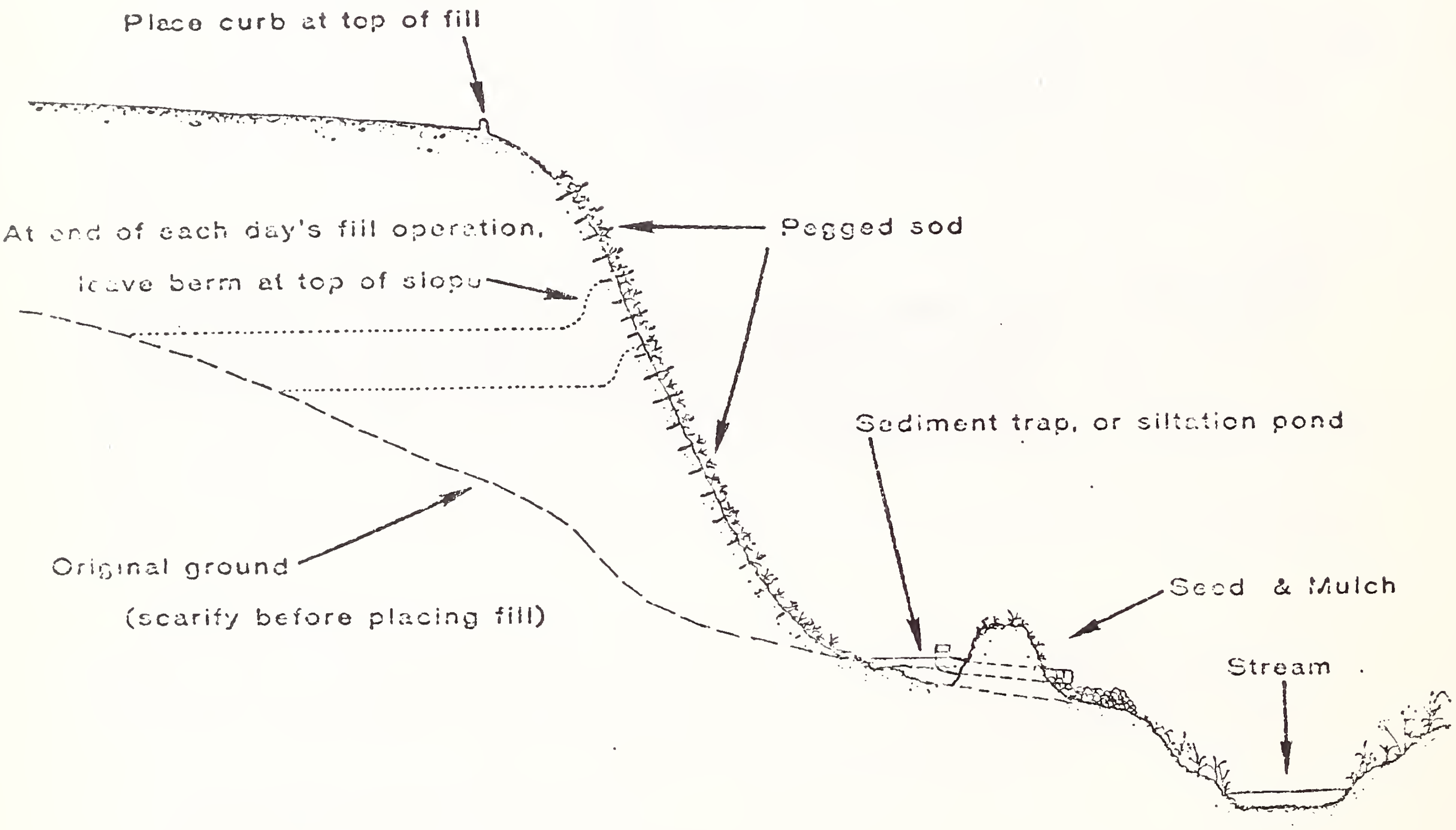

Place curb at top of fill
At end of each day's fill operation, leave berm at top of slope
Pegged sod
Sediment trap, or siltation pond
Seed & Mulch
Stream
Original ground (scarify before placing fill)

Fig. 75-14: Idealized profile of construction area with many temporary erosion and sediment control measures installed.

BURLAP EMBANKMENT PROTECTORS

By D. J. Silver
Area Engineer
Utah Division
Federal Highway Administration
Department of Transportation

On Federal-aid Project F-015-2(8) Second Contract, the State of Utah specified burlap embankment protectors in lieu of concrete or bituminous curb to control the fill erosion along this project. The project is rural primary traversing a predominately sandstone formation. The embankments are built with sandstone that erodes easily the first few years from water running off the pavement. In order to control this erosion, the highway department had the choice of placing bituminous curb, concrete curb, or burlap embankment protector. The highway department decided to utilize the burlap embankment protector for several reasons: (1) more economical, (2) easier to remove once soil stabilization has been accomplished, (3) easier to install, (4) more flexible and versatile than the other types of curb, and (5) safer.

The initial installation on Project F-015-2(8) Second Conctract, confirms the assumptions for basic advantages. Bid prices on this project range from $0.50 to $2.00 per lineal foot with the low bidder bidding $0.60 per lineal foot. In 1969, approximately the same amount of asphalt curb was installed in the State of Utah and the bid price for this was $1.99 per lineal foot. Concrete curb, which is used extensively, costs $1.58 per lineal foot. It, therefore, has proven to be a more economical product to accomplish the same ends.

The other four assumptions, ease of installation, flexibility, ease of removal. and safety, have been confirmed on this project. Since the burlap curb is an independent structure, its location is not restricted as is the case with the other types of curb. Figure 3 denotes a typical installation along the embankment. The curb is located outside the 30-foot recovery zone, whereas, the other types of curb have to be placed on the pavement and within the recovery zone. On barn roof typical sections, the burlap curb could be placed out of sight, thereby, eliminating the necessity for removal. The burlap curb was placed after all of the other roadway appurtenances, guardrail, delineators, etc., had been installed. Therefore, the curbing operation did not interfere with or restrict other installations on the project, which is not true of the other types of curb. Figure 4 denotes a typical section using this curb and guardrail along the slope. The curb location back of the guardrail provides a safer installation than a curb underneath the rail and in front of the post. Additional advantage from this type of erosion control is that it can be utilized by maintenance forces and repaired much more easily than other types of curb.

The installation was accomplished by three laborers, an end-dump truck, and a front-end loader; versus a central batch plant and other elaborate equipment to place the other types curb. Following is a force account breakdown of cost to install 5,280 feet of burlap embankment protector on Project F-015-2(8) Second Contract:

Item	Hours	Rate	Amount
Truck Driver	64	$ 4.10	$ 262.40
Laborer	128	3.58	458.24
Front-end Loader 4 cubic yards	16	21.65	346.40
End-dump Truck 10 cubic yards	64	10.90	697.60
Burlap - 1406 square yards		0.22	309.32
Sand - 160 cubic yards		0.50	80.00
		Total Cost	$2,152.96

Which equals contractor's cost of $0.41 per lineal foot to install this type of embankment protector.

Contractor's Operation - Burlap was sewn in a manner to form a 1-foot diameter tube 25 feet long. These tubes were threaded onto an offset chute attached to the 10-cubic yard end-dump truck. Sand was put into the tube and the tube was laid in a preformed ditch on the ground. The crew included a truck driver, a laborer feeding sand into the tube and a laborer placing the tube in the final position. When the tubes were filled and the truck returned for another load, the two laborers would align the embankment protector, and backfill the haunch between the tube and the ditch.

The above description was of the actual operation. There are a few additional items which may aid the prospective user of this burlap embankment protector. The burlap can be ordered either in bags or in flat bolts in widths of 36 inches or 40 inches. The supplier of the burlap for this project, Fulton-Denver Company. 3500 Wynkoop Street, Denver, Colorado, does not sew the flat burlap into tubes; therefore, it must be sewn by the contractor or subbed out. The burlap can be filled with any type of earth,but for ease of construction,sand was specified. The contractor did have the option of using other materials as the specification stated, "...tubing filled with sand or other materials approved by the engineer..."

DIRECTOR
HENRY C. HELLAND

STATE HIGHWAY ENGINEER
BLAINE J. KAY

Utah State Department of Highways
State Office Building
Salt Lake City, Utah 84114

MONTANA HIGHWAY COMMISSION
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DIRECTOR
CENTRALIZED SERVICES
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BRIDGE
CONSTRUCTION
MATERIALS
RIGHT-OF-WAY
LEGAL
MAINTENANCE
MOTOR POOL
PERSONNEL
OTHER

July 19, 1972

State of Montana
Department of Highways
Helena, Montana 59601

ATTENTION: Grover O. Powers, P.E.
Supervisor - Preconstruction Section

Gentlemen:

SUBJECT: Burlap Embankment Protectors

In reply to your letter of June 20, 1972, we are able to offer the following comments from individuals who have worked with the installation of burlap embankment protectors.

Mr. Myron Taylor was Project Construction Engineer three years ago when this type of treatment was first used. He offers the following suggestions and information:

(1) W. W. Clyde Company of Springville, Utah was the contractor. They obtained rolls of waterproof burlap and sewed the material into tubes 25 feet long. They attached a stove pipe type tube to a dump truck bed with a control gate and threaded the burlap tube over the pipe before starting to sand fill the burlap tube. The truck moved along the road as the tube filled.

(2) It was necessary to provide a nesting place in the soil along the road shoulder. This depression should be 2-3 inches deep and rounded to fit the burlap tube. If care wasn't taken in this type of placement, water would run under the tubing and cause erosion.

(3) Observation by our Hydraulics Engineer indicates that after three years the burlap is starting to decompose, but that the sand ridge is remaining and should control water runoff for several more years.

"safe today - alive tomorrow"

This project had 5000 lin. ft. of tubing installed at the contract bid price of $0.60 per foot.

The Bemis Bag Co. here in Salt Lake has 9-inch wide burlap tubing at a cost of $60.00 per hundred pounds. One roll of 175 yards weighs 40 pounds. It comes in 7½ oz. and 10 oz. material. This material is not waterproof and would cost extra for waterproofing. They suggest using woven polypropylene that also comes in 9-inch wide tubing at a cost of $30.00 per 300 yard roll.

Comments of those who have observed this type of embankment treatment feel it offers a favorable solution to control of road surface runoff until vegetation is able to provide sufficient embankment protection.

Very truly yours,

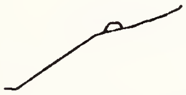
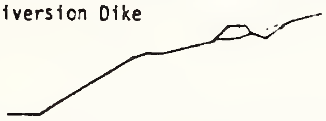
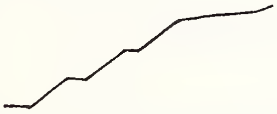
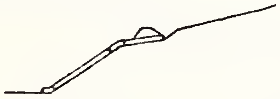
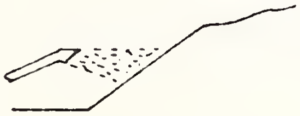
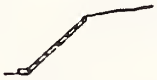
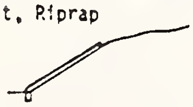
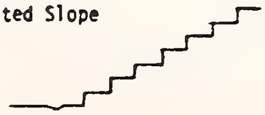
Emery M. Larson

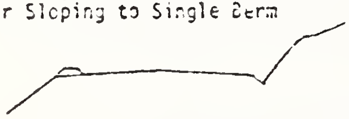
EMERY M. LARSON
Landscape Architect

Attachment

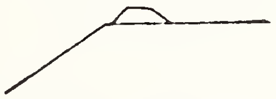
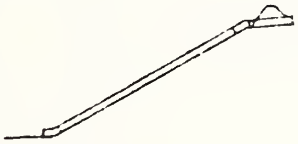
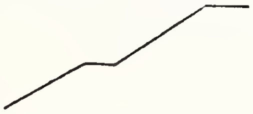
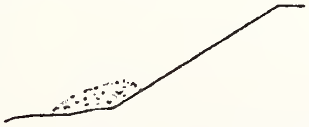
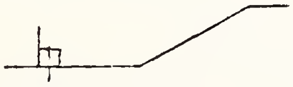
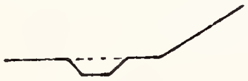
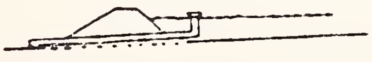
Date Recd. Preconst. 7-26-72
Info
ROUTE
Attach
Road Design
Engineers
Region
Consultant Design

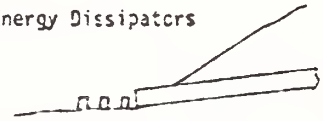
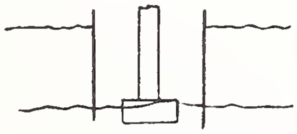
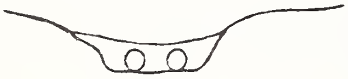
Erosion Control Practice

Treatment Practice	Advantages	Problems
CUT SLOPES		
Berm @ top of cut 	Diverts water from cut Collects water for slope drains/paved ditches May be constructed before grading is started	Access to top of cut Difficult to build on steep natural slope or rock surface Concentrates water and may require channel protection or energy dissipation devices Can cause water to enter ground, resulting in sloughing of the cut slope
Diversion Dike 	Collects and diverts water at a location selected to reduce erosion potential May be incorporated in the permanent project drainage	Access for construction May be continuing maintenance problem if not paved or protected Disturbed material or berm is easily eroded
Slope Benches 	Slows velocity of surface runoff Collects sediment Provides access to slope for seeding, mulching, and maintenance Collects water for slope drains or may divert water to natural ground	May cause sloughing of slopes if water infiltrates Requires additional ROW Not always possible due to rotten material etc. Requires maintenance to be effective Increases excavation quantities
Slope Drains (pipe, paved, etc.) 	Prevents erosion on the slope Can be temporary or part of permanent construction Can be constructed or extended as grading progresses	Requires supporting effort to collect water Permanent construction is not always compatible with other project work Usually requires some type of energy dissipation
Seeding/Mulching 	The end objective is to have a completely grassed slope. Early placement is a step in this direction. The mulch provides temporary erosion protection until grass is rooted. Temporary or permanent seeding may be used. Mulch should be anchored. Larger slopes can be seeded and mulched with smaller equipment if stage techniques are used.	Difficult to schedule high production units for small increments Time of year may be less desirable May require supplemental water Contractor may perform this operation with untrained or unexperienced personnel and inadequate equipment if stage seeding is required
Sodding 	Provides immediate protection Can be used to protect adjacent property from sediment and turbidity	Difficult to place until cut is complete Sod not always available May be expensive
Pavement, Riprap 	Provides immediate protection for high risk areas and under structures May be cast in place or off site	Expensive Difficult to place on high slopes
Temporary Cover	Plastics are available in wide rolls and large sheets that may be used to provide temporary protection for cut or fill slopes Easy to place and remove Useful to protect high risk areas from temporary erosion	Provides only temporary protection Original surface usually requires additional treatment when plastic is removed Must be anchored to prevent wind damage
Serrated Slope 	Lowers velocity of surface runoff Collects sediment Holds moisture Minimizes amount of sediment reaching roadside ditch	May cause minor sloughing if water infiltrates Construction compliance

Treatment Practice	Advantages	Problems
ROADWAY DITCHES		
Check Dams	Maintain low velocities Catch sediment Can be constructed of logs, shot rock, lumber, masonry or concrete	Close spacing on steep grades Require clean-out Unless keyed at sides and bottom, erosion may occur
Sediment Traps/ Straw Bale Filters	Can be located as necessary to collect sediment during construction Clean-out often can be done with on-the-job equipment Simple to construct	Little direction on spacing and size Sediment disposal may be difficult Specification must include provisions for periodic clean-out May require seeding, sodding or pavement when removed during final cleanup
Sodding	Easy to place with a minimum of preparation Can be repaired during construction Immediate protection May be used to provide increased capacity for paved ditches	Requires water during first few weeks Sod not always available Will not withstand high velocity or severe abrasion from sediment load
Seeding with Mulch and Matting	Usually least expensive Effective for ditches with low velocity Easily placed in small quantities with inexperienced personnel	Will not withstand medium to high velocity
Paving, Riprap, Rubble	Effective for high velocities May be part of the permanent erosion control effort	Cannot always be placed when needed because of construction traffic and final grading and dressing Initial cost is high
ROADWAY SURFACE		
Crowning to Ditch or Sloping to Single Berm 	Directing the surface water to a prepared or protected ditch minimizes erosion	None - should be part of good construction procedures
Compaction	The final lift of each day's work should be well compacted and bladed to drain to ditch or berm section. Loose or uncompacted material is more subject to erosion	None - should be part of good construction procedures
Aggregate Cover	Minimizes surface erosion Permits construction traffic during adverse weather May be used as part of permanent base construction	Requires reworking and compaction if exposed for long periods of time Loss of surface aggregates can be anticipated
Seed/Mulch	Minimizes surface erosion	Must be removed or is lost when construction of pavement is commenced

CONSTRUCTION DETAILS

Treatment Practice	Advantages	Problems
FILL SLOPES		
Berms at Top of Embankment 	Prevent runoff from embankment surface from flowing over face of fill Collect runoff for slope drains or protected ditch Can be placed as a part of the normal construction operation and incorporated into fill or shoulders	Cooperation of construction operators to place final lifts at edge for shaping into berm Failure to compact outside lift when work is resumed Sediment buildup and berm failure
Slope Drains 	Prevent fill slope erosion caused by embankment surface runoff Can be constructed of full or half section pipe, bituminous, metal, concrete, plastic, or other waterproof material Can be extended as construction progresses May be either temporary or permanent	Permanent construction as needed may not be considered desirable by contractor Removal of temporary drains may disturb growing vegetation Energy dissipation devices are required at the outlets
Fill Berms or Benches 	Slows velocity of slope runoff Collects sediment Provides access for maintenance Collects water for slope drains May utilize waste	Requires additional fill material if waste is not available May cause sloughing Additional ROW may be needed
Seeding/Mulching	Timely application of mulch and seeding decreases the period a slope is subject to severe erosion Mulch that is cut in or otherwise anchored will collect sediment. The furrows made will also hold water and sediment	Seeding season may not be favorable Not 100 percent effective in preventing erosion Watering may be necessary Steep slopes or locations with low velocities may require supplemental treatment
PROTECTION OF ADJACENT PROPERTY		
Brush Barriers 	Use slashing and logs from clearing operation Can be covered and seeded rather than removed Eliminates need for burning or disposal off ROW	May be considered unsightly in urban areas
Straw Bale Barriers 	Straw is readily available in many areas When properly installed, they filter sediment and some turbidity from runoff	Require removal Subject to vandal damage Flow is slow through straw requiring considerable area
Sediment Traps 	Collect much of the sediment spill from fill slopes and storm drain ditches Inexpensive Can be cleaned and expanded to meet need	Do not eliminate all sediment and turbidity Space is not always available Must be removed (usually)
Sediment Pools 	Can be designed to handle large volumes of flow Both sediment and turbidity are removed May be incorporated into permanent erosion control plan	Require prior planning, additional ROW and/or flow easement If removal is necessary, can present a major effort during final construction stage Clean-out volumes can be large Access for clean-out not always convenient

Treatment Practice	Advantages	Problems
Energy Dissipators 	Slow velocity to permit sediment collection and to minimize channel erosion off project	Collect debris and require cleaning Require special design and construction of large shot rock or other suitable material from project
Level Spreaders	Convert collected channel or pipe flow back to sheet flow Avoid channel easements and construction off project Simple to construct	Adequate spreader length may not be available Seeding of overflow berm is usually required Must be a part of the permanent erosion control effort Maintenance forces must maintain spreader until no longer required
PROTECTION OF STREAM		
Construction Dike	Permits work to continue during normal stream stages Controlled flooding can be accomplished during periods of inactivity	Usually requires pumping of work site water into sediment pond Subject to erosion from stream and from direct rainfall on dike
Cofferdam 	Work can be continued during most anticipated stream conditions Clear water can be pumped directly back into stream No material deposited in stream	More expensive
Temporary Stream Channel Change	Prepared channel keeps normal flows away from construction	New channel usually will require protection Stream must be returned to old channel and temporary channel refilled
Riprap	Sacked sand with cement or stone easy to stockpile and place Can be installed in increments as needed	
Temporary Culverts for Haul Roads 	Eliminate stream turbulence and turbidity Provide unobstructed passage for fish and other water life Capacity for normal flow can be provided with storm water flowing over the roadway	Space not always available without conflicting with permanent structure work May be expensive, especially for larger sizes of pipe Subject to washout
Rock-lined Low-Level Crossing	Minimizes stream turbidity Inexpensive May also serve as ditch check or sediment trap	May not be fordable during rainstorms During periods of low flow passage of fish may be blocked

Treatment Practice	Advantages	Problems
BORROW AREAS		
Selective Grading and Shaping	Water can be directed to minimize off-site damage Flatter slopes enable mulch to be cut into soil	May not be most economical work method for contractor
Stripping and Replacing of Topsoil	Provides better seed bed Conventional equipment can be used to stockpile and spread topsoil	May restrict volume of material that can be obtained for a site Topsoil stockpiles must be located to minimize sediment damage Cost of rehandling material
Dikes, Berms Diversion Ditches Settling Basins Sediment Traps Seeding & Mulch	See other practices	See other practices

BORROW CONSTRUCTION CO.

A MONTANA CORPORATION

P.O. Box 000 Two Dot, Montana

John Doe, Mgr. F.P.U.II
Montana Department of Highways
Helena, Montana 59601

Dear Sirs:

The attached temporary erosion control plan is submitted for your approval. A proposed solution is included for all anticipated problem areas. However, any unforeseen problems that arise and any proposed solutions that prove inadequate will be remedied appropriately during construction.

Very truly yours,

Borrow Construction Co.

BCC:pz

Attachment

SAMPLE

TEMPORARY EROSION CONTROL PLAN

A comprehensive analysis of this project shows that for the major part of the project very little temporary erosion control will be necessary. A preliminary classification of the soil types on this job shows that any water velocity below 3 fps can be considered non-erosive. However, as in any analysis there will be isolated areas that will require jobsite remedies as the excavation proceeds.

The measures that are apparent at this time are as detailed below.

From stations 557+00 to 562+00 right and left there should be ditch barriers constructed approximately 6 inches high on approximately one hundred foot intervals. Also to be constructed in this area are catch basins on both sides of the cattle underpass at Station 564+00.

From stations 605+00 to 627+00 left will probably require an interceptor ditch above the 1½:1 cut slope, and 6 inch ditch barriers at 100 foot intervals. Also in this area if there is an eminent threat of runoff during the installation of the pipe at Station 625+50 there should be a dike constructed to retain any silt generated through this operation.

From station 673+00 to 691+00 both sides and 700+00 to 740+00 left should have 6 inch ditch barriers constructed at 100 foot intervals with catch basins constructed as required to accomodate the runoff. Stations 700+00 to 740+00 left should also have an interceptor ditch above the backslope.

At station 739+70 (Skunk Creek) unless the water can be kept in the existing pipe during the installation of the new pipe it should be diverted through another pipe set high enough to form a silt basin at the inlet and care used to prevent the trapped silt from being discharged when this temporary measure is removed.

At stations 750+00 to 775+00 right an interceptor ditch should be constructed above the 1½:1 backslope with provisions made to dispose of the flow from this ditch in such a way to stop the flow of silt into the road ditch.

All of the above facilities except for the interceptor ditch shall be removed prior to placement of topsoil and in such a schedule that will not allow erosion to take place before the placement of the topsoil.

Seeding will be accomplished as soon as practical after the placement of the topsoil.

All labor, equipment and materials used in the above plan and found necessary for temporary erosion control during the construction of this project will be paid by the State as detailed in Section 9.04(B) of the Montana Standard Specifications.

WELL, DUDLEY, OL' BUDDY, THERE'S OUR TEMPORARY EROSION CONTROL. THAT SHEET PILING WILL CATCH ALL THE SOIL THAT WASHES OFF THE SLOPES, AND THEN WE'LL PACK IT BACK UP HERE.
SKRUDE CONST. CO.
LOREN DOLLAH

CHAPTER V
APPENDIX

CONSTRUCTION MANUAL

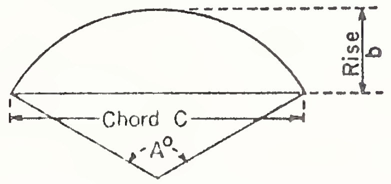
CHAPTER V

APPENDIX

FIGURE	TITLE
V-1	Areas of circular segments
V-2	Length of circular arcs for unit radius
V-3	Aggregate spreads
V-4	Linear feet of spread for liquid asphalt
V-5	Capacity chart for cylindrical tanks
V-6	Skew areas of CMP
V-7	Skew areas of RCP
V-8	Theoretical surface ditch end areas for 2% slope change
V-9	Standard slope rounding end areas for 5% slope change
V-10	Conversion of minutes and seconds to decimal parts of a degree

AREAS OF CIRCULAR SEGMENTS

Table I– For Ratios of Rise and Chord



Area = C x b x coefficient

A°	Coefficient	$\frac{b}{C}$	A°	Coefficient	$\frac{b}{C}$	A°	Coefficient	$\frac{b}{C}$	A°	Coefficient	$\frac{b}{C}$
1	.6667	.0022	46	.6722	.1017	91	.6895	.2097	136	.7239	.3373
2	.6667	.0044	47	.6724	.1040	92	.6901	.2122	137	.7249	.3404
3	.6667	.0066	48	.6727	.1003	93	.6906	.2148	138	.7260	.3436
4	.6667	.0087	49	.6729	.1086	94	.6912	.2174	139	.7270	.3469
5	.6667	.0109	50	.6732	.1109	95	.6918	.2200	140	.7281	.3501
6	.6667	.0131	51	.6734	.1131	96	.6924	.2226	141	.7292	.3534
7	.6668	.0153	52	.6737	.1154	97	.6930	.2252	142	.7303	.3567
8	.6668	.0175	53	.6740	.1177	98	.6936	.2279	143	.7314	.3600
9	.6669	.0197	54	.6743	.1200	99	.6942	.2305	144	.7325	.3633
10	.6670	.0218	55	.6746	.1224	100	.6948	.2332	145	.7336	.3666
11	.6670	.0240	56	.6749	.1247	101	.6954	.2358	146	.7348	.3700
12	.6671	.0262	57	.6752	.1270	102	.6961	.2385	147	.7360	.3734
13	.6672	.0284	58	.6755	.1293	103	.6967	.2412	148	.7372	.3768
14	.6672	.0306	59	.6758	.1316	104	.6974	.2439	149	.7384	.3802
15	.6673	.0328	60	.6761	.1340	105	.6980	.2466	150	.7396	.3837
16	.6674	.0350	61	.6764	.1363	106	.6987	.2493	151	.7408	.3871
17	.6674	.0372	62	.6768	.1387	107	.6994	.2520	152	.7421	.3906
18	.6675	.0394	63	.6771	.1410	108	.7001	.2548	153	.7434	.3942
19	.6676	.0416	64	.6775	.1434	109	.7008	.2575	154	.7447	.3977
20	.6677	.0437	65	.6779	.1457	110	.7015	.2603	155	.7460	.4013
21	.6678	.0450	66	.6782	.1481	111	.7022	.2631	156	.7473	.4049
22	.6679	.0481	67	.6786	.1505	112	.7030	.2659	157	.7486	.4085
23	.6680	.0504	68	.6790	.1529	113	.7037	.2687	158	.7500	.4122
24	.6681	.0526	69	.6794	.1553	114	.7045	.2715	159	.7514	.4159
25	.6682	.0548	70	.6797	.1577	115	.7052	.2743	160	.7528	.4196
26	.6684	.0570	71	.6801	.1601	116	.7060	.2772	161	.7542	.4233
27	.6685	.0592	72	.6805	.1625	117	.7068	.2800	162	.7557	.4270
28	.6687	.0614	73	.6809	.1649	118	.7076	.2829	163	.7571	.4308
29	.6688	.0636	74	.6814	.1673	119	.7084	.2858	164	.7586	.4346
30	.6690	.0658	75	.6818	.1697	120	.7092	.2887	165	.7601	.4385
31	.6691	.0681	76	.6822	.1722	121	.7100	.2916	166	.7616	.4424
32	.6693	.0703	77	.6826	.1746	122	.7109	.2945	167	.7632	.4463
33	.6694	.0725	78	.6831	.1771	123	.7117	.2975	168	.7648	.4502
34	.6696	.0747	79	.6835	.1795	124	.7126	.3004	169	.7664	.4542
35	.6698	.0770	80	.6840	.1820	125	.7134	.3034	170	.7680	.4582
36	.6700	.0792	81	.6844	.1845	126	.7143	.3064	171	.7696	.4622
37	.6702	.0814	82	.6849	.1869	127	.7152	.3094	172	.7712	.4663
38	.6704	.0837	83	.6854	.1894	128	.7161	.3124	173	.7729	.4704
39	.6706	.0859	84	.6859	.1919	129	.7170	.3155	174	.7746	.4745
40	.6708	.0882	85	.6884	.1944	130	.7180	.3185	175	.7763	.4787
41	.6710	.0904	86	.6869	.1970	131	.7189	.3216	176	.7781	.4828
42	.6712	.0927	87	.6874	.1995	132	.7199	.3247	177	.7799	.4871
43	.6714	.0949	88	.6879	.2020	133	.7209	.3278	178	.7817	.4914
44	.6717	.0972	89	.6884	.2046	134	.7219	.3309	179	.7835	.4957
45	.6719	.0995	90	.6890	.2071	135	.7229	.3341	180	.7854	.5000

LENGTH OF CIRCULAR ARCS FOR UNIT RADIUS

By the use of this table, the length of any arc may be found if the length of the radius and the angle of the segment are known.

Example:—Required the length of arc of segment of 32°15'27" with radius of 24 feet 3 inches.
From table: Length of arc (Radius 1) for 32° = .5585054
15' = .0043633
27" = .0001309
.5629996
.5629996 X 24.25 (length of radius) = 13.65 feet

DEGREES						MINUTES		SECONDS	
1°	.017 4633	61°	1.064 6508	121°	2.111 8484	1'	.000 2909	1"	.000 0048
2	.034 9066	62	1.082 1041	122°	2.129 3017	2	.000 5818	2	.000 0097
3	.052 3599	63	1.099 5574	123	2.146 7550	3	.000 8727	3	.000 0145
4	.069 8132	64	1.117 0107	124	2.164 2083	4	.001 1636	4	.000 0194
5	.087 2665	65	1.134 4640	125	2.181 6616	5	.001 4544	5	.000 0242
6	.104 7198	66	1.151 9173	126	2.199 1149	6	.001 7453	6	.000 0291
7	.122 1730	67	1.169 3706	127	2.216 5682	7	.002 0362	7	.000 0339
8	.139 6263	68	1.186 8239	128	2.234 0214	8	.002 3271	8	.000 0388
9	.157 0796	69	1.204 2772	129	2.251 4747	9	.002 6180	9	.000 0436
10	.174 5329	70	1.221 7305	130	2.268 9280	10	.002 9089	10	.000 0485
11	.191 9862	71	1.239 1838	131	2.286 3813	11	.003 1998	11	.000 0533
12	.209 4395	72	1.256 6371	132	2.303 8346	12	.003 4907	12	.000 0582
13	.226 8928	73	1.274 0904	133	2.321 2879	13	.003 7815	13	.000 0630
14	.244 3461	74	1.291 5436	134	2.338 7412	14	.004 0724	14	.000 0679
15	.261 7994	75	1.308 9969	135	2.356 1945	15	.004 3633	15	.000 0727
16	.279 2527	76	1.326 4502	136	2.373 6478	16	.004 6542	16	.000 0776
17	.296 7060	77	1.343 9035	137	2.391 1011	17	.004 9451	17	.000 0824
18	.314 1593	78	1.361 3568	138	2.408 5544	18	.005 2360	18	.000 0873
19	.331 6126	79	1.378 8101	139	2.426 0077	19	.005 5269	19	.000 0921
20	.349 0659	80	1.396 2634	140	2.443 4610	20	.005 8178	20	.000 0970
21	.366 5191	81	1.413 7167	141	2.460 9142	21	.006 1087	21	.000 1018
22	.383 9724	82	1.431 1700	142	2.478 3675	22	.006 3995	22	.000 1067
23	.401 4257	83	1.448 6233	143	2.495 8206	23	.006 6904	23	.000 1115
24	.418 8790	84	1.466 0766	144	2.513 2741	24	.006 9813	24	.000 1164
25	.436 3323	85	1.483 5299	145	2.530 7274	25	.007 2722	25	.000 1212
26	.453 7856	86	1.500 9832	146	2.548 1807	26	.007 5631	26	.000 1261
27	.471 2389	87	1.518 4364	147	2.565 6340	27	.007 8540	27	.000 1309
28	.488 6922	88	1.635 8897	148	2.583 0873	28	.008 1449	28	.000 1357
29	.506 1455	89	1.553 3430	149	2.600 5406	29	.008 4358	29	.000 1406
30	.523 5988	90	1.570 7963	150	2.617 9939	30	.008 7266	30	.000 1454
31	.541 0521	91	1.588 2496	151	2.635 4472	31	.009 0175	31	.000 1503
32	.558 5054	92	1.605 7029	152	2.652 9005	32	.009 3084	32	.000 1551
33	.575 9587	93	1.623 1562	153	2.670 3538	33	.009 5993	33	.000 1600
34	.593 4119	94	1.640 6095	154	2.687 8070	34	.009 8902	34	.000 1648
35	.610 8652	95	1.658 0628	155	2.705 2603	35	.010 1811	35	.000 1697
36	.628 3185	96	1.675 5161	156	2.722 7136	36	.010 4720	36	.000 1745
37	.645 7718	97	1.692 9694	157	2.740 1669	37	.010 7629	37	.000 1794
38	.663 2251	98	1.710 4227	158	2.757 6202	38	.011 0538	38	.000 1842
39	.680 6784	99	1.727 8760	159	2.775 0735	39	.011 3446	39	.000 1891
40	.698 1317	100	1.745 3293	160	2.792 5268	40	.011 6355	40	.000 1939
41	.715 5850	101	1.762 7825	161	2.809 9801	41	.011 9264	41	.000 1988
42	.733 0383	102	1.780 2358	162	2.827 4334	42	.012 2173	42	.000 2036
43	.750 4916	103	1.797 6891	163	2.844 8867	43	.012 5082	43	.000 2085
44	.767 9449	104	1.815 1424	164	2.862 3400	44	.012 7991	44	.000 2133
45	.785 3982	105	1.832 5957	165	2.879 7933	45	.013 0900	45	.000 2182
46	.802 8515	106	1.850 0490	166	2.897 2466	46	.013 3809	46	.000 2230
47	.820 3047	107	1.867 5023	167	2.914 6999	47	.013 6717	47	.000 2279
48	.837 7580	108	1.884 9556	168	2.932 1531	48	.013 9626	48	.000 2327
49	.855 2113	109	1.902 4089	169	2.949 6064	49	.014 2535	49	.000 2376
50	.872 6646	110	1.919 8622	170	2.967 0597	50	.014 5444	50	.000 2424
51	.890 1179	111	1.937 3155	171	2.984 5130	51	.014 8353	51	.000 2473
52	.907 5712	112	1.954 7688	172	3.001 9663	52	.015 1262	52	.000 2521
53	.925 0245	113	1.972 2221	173	3.019 4196	53	.015 4171	53	.000 2570
54	.942 4778	114	1.989 6753	174	3.036 8729	54	.015 7080	54	.000 2618
55	.959 9311	115	2.007 1286	175	3.054 3262	55	.015 9989	55	.000 2666
56	.977 3844	116	2.024 5819	176	3.071 7795	56	.016 2897	56	.000 2715
57	.994 8377	117	2.042 0352	177	3.089 2328	57	.016 5806	57	.000 2763
58	1.012 2910	118	2.059 4885	178	3.106 6861	58	.016 8715	58	.000 2812
59	1.029 7443	119	2.076 0418	179	3.124 1394	59	.017 1624	59	.000 2860
60	1.047 1976	120	2.094 3951	180	3.141 5927	60	.017 4533	60	.000 2909

SPEC. GRAV.	TONS PER		TONS PER STATION PER FOOT WIDTH OF ROADBED																							
	CU FT	CU YD	1/2"	1½"	2"	2½"	3"	3½"	4"	5"	6"	7"	8"	9"	10"	11"	12"	13"	14"	15"	16"	17"	18"	19"	20"	21"	22"	23"	24"
2.35	0.06599	1.782	0.275	0.825	1.100	1.375	1.650	1.925	2.200	2.750	3.300	3.849	4.400	4.949	5.499	6.049	6.599	7.149	7.699	8.249	8.799	9.349	9.899	10.448	10.999	11.548	12.098	12.648	13.198
2.40	0.06739	1.820	0.281	0.842	1.123	1.404	1.685	1.966	2.246	2.808	3.370	3.931	4.493	5.054	5.616	6.178	6.739	7.300	7.862	8.424	8.985	9.547	10.109	10.670	11.232	11.793	12.355	12.917	13.478
2.45	0.06880	1.858	0.287	0.860	1.147	1.433	1.720	2.007	2.293	2.867	3.440	4.013	4.587	5.160	5.733	6.307	6.880	7.453	8.027	8.600	9.173	9.747	10.320	10.893	11.467	12.040	12.613	13.187	13.760
2.48	0.06964	1.880	0.290	0.871	1.161	1.451	1.741	2.031	2.321	2.902	3.482	4.062	4.643	5.223	5.803	6.384	6.964	7.544	8.125	8.705	9.285	9.866	10.446	11.026	11.607	12.187	12.767	13.348	13.928
2.49	0.06992	1.888	0.292	0.874	1.166	1.457	1.748	2.040	2.331	2.914	3.496	4.079	4.662	5.244	5.827	6.410	6.992	7.575	8.158	8.740	9.323	9.906	10.488	11.071	11.654	12.236	12.819	13.402	13.984
2.50	0.07020	1.895	0.293	0.878	1.170	1.462	1.755	2.048	2.340	2.925	3.510	4.095	4.680	5.265	5.850	6.435	7.020	7.605	8.190	8.775	9.360	9.945	10.530	11.115	11.700	12.285	12.870	13.455	14.040
2.51	0.07048	1.903	0.294	0.881	1.175	1.468	1.762	2.056	2.349	2.937	3.524	4.111	4.699	5.236	5.873	6.461	7.048	7.633	8.223	8.810	9.397	9.985	10.572	11.159	11.747	12.334	12.921	13.509	14.096
2.52	0.07076	1.911	0.295	0.885	1.180	1.474	1.769	2.064	2.359	2.949	3.538	4.128	4.718	5.307	5.897	6.487	7.076	7.666	8.256	8.845	9.435	10.025	10.614	11.204	11.794	12.383	12.973	13.563	14.152
2.53	0.07104	1.918	0.296	0.888	1.184	1.480	1.776	2.072	2.368	2.960	3.552	4.144	4.736	5.328	5.920	6.512	7.104	7.696	8.288	8.880	9.472	10.064	10.656	11.248	11.840	12.432	13.024	13.616	14.208
2.54	0.07132	1.926	0.297	0.892	1.189	1.486	1.783	2.081	2.377	2.972	3.566	4.160	4.755	5.349	5.943	6.538	7.132	7.726	8.321	8.915	9.509	10.104	10.698	11.292	11.887	12.481	13.075	13.670	14.264
2.55	0.07160	1.933	0.299	0.895	1.194	1.492	1.790	2.089	2.387	2.984	3.580	4.177	4.774	5.370	5.967	6.564	7.160	7.757	8.354	8.950	9.547	10.144	10.740	11.337	11.934	12.530	13.127	13.724	14.320
2.56	0.07189	1.941	0.300	0.899	1.199	1.498	1.797	2.097	2.396	2.996	3.595	4.193	6.793	5.392	5.991	6.590	7.189	7.788	8.387	8.986	9.585	10.185	10.784	11.382	11.982	12.581	13.180	13.779	14.378
2.57	0.07217	1.949	0.301	0.902	1.203	1.503	1.804	2.105	2.406	3.007	3.609	4.210	4.812	5.413	6.014	6.616	7.217	7.818	8.420	9.021	9.623	10.224	10.826	11.427	12.029	12.630	13.231	13.833	14.434
2.58	0.07245	1.956	0.302	0.906	1.208	1.509	1.811	2.113	2.415	3.019	3.623	4.226	4.830	5.434	6.032	6.642	7.245	7.849	8.453	9.056	9.660	10.264	10.868	11.471	12.075	12.679	13.282	13.887	14.490
2.59	0.07273	1.964	0.303	0.909	1.213	1.515	1.818	2.122	2.424	3.031	3.637	4.242	4.849	5.455	6.061	6.667	7.273	7.879	8.486	9.091	9.697	10.304	10.910	11.515	12.122	12.728	13.334	13.940	14.546
2.60	0.07301	1.971	0.305	0.913	1.217	1.521	1.825	2.130	2.434	3.042	3.651	4.259	4.868	5.476	6.084	6.693	7.301	7.909	8.518	9.126	9.735	10.343	10.952	11.560	12.169	12.777	13.385	13.994	14.602
2.61	0.07329	1.979	0.306	0.916	1.222	1.527	1.832	2.138	2.443	3.054	3.665	4.275	4.886	5.497	6.107	6.719	7.329	7.940	8.551	9.161	9.772	10.383	10.994	11.604	12.215	12.826	13.436	14.048	14.658
2.62	0.07357	1.986	0.307	0.920	1.227	1.533	1.839	2.146	2.452	3.066	3.679	4.291	4.905	5.518	6.131	6.744	7.357	7.970	8.584	9.196	9.809	10.423	11.036	11.648	12.262	12.875	13.488	14.101	14.714
2.63	0.07385	1.994	0.308	0.923	1.231	1.538	1.846	2.154	2.462	3.077	3.693	4.308	4.924	5.539	6.154	6.770	7.385	8.000	8.616	9.231	9.847	10.462	11.078	11.693	12.309	12.924	13.539	14.155	14.770
2.64	0.07413	2.002	0.309	0.927	1.236	1.544	1.853	2.162	2.471	3.089	3.707	4.324	4.942	5.560	6.177	6.796	7.413	8.031	8.649	9.266	9.884	10.502	11.120	11.737	12.355	12.973	13.590	14.209	14.826
2.65	0.07441	2.009	0.310	0.930	1.941	1.550	1.860	2.171	2.480	3.101	3.721	4.340	4.961	5.581	6.201	6.821	7.441	8.061	8.682	9.301	9.921	10.542	11.162	11.781	12.402	13.022	13.642	14.262	14.882
2.70	0.07582	2.047	0.316	0.948	1.264	1.579	1.896	2.212	2.527	3.160	3.791	4.423	5.055	5.687	6.318	6.951	7.582	8.214	8.846	9.478	10.109	10.742	11.373	12.005	12.637	13.269	13.900	14.533	15.164
2.75	0.07722	2.085	0.322	0.965	1.287	1.609	1.931	2.253	2.574	3.218	3.861	4.504	5.148	5.792	6.435	7.079	7.722	8.365	9.009	9.653	10.296	10.940	11.583	12.226	12.870	13.514	14.157	14.801	15.444
2.80	0.07862	2.123	0.328	0.983	1.311	1.638	1.966	2.293	2.621	3.276	3.931	4.586	5.242	5.897	6.552	7.207	7.862	8.517	9.173	9.828	10.483	11.138	11.793	12.448	13.104	13.759	14.413	15.069	15.724

Formula: 62.4 x 0.90 x specific gravity ÷ 2000 = tons per cu. ft.

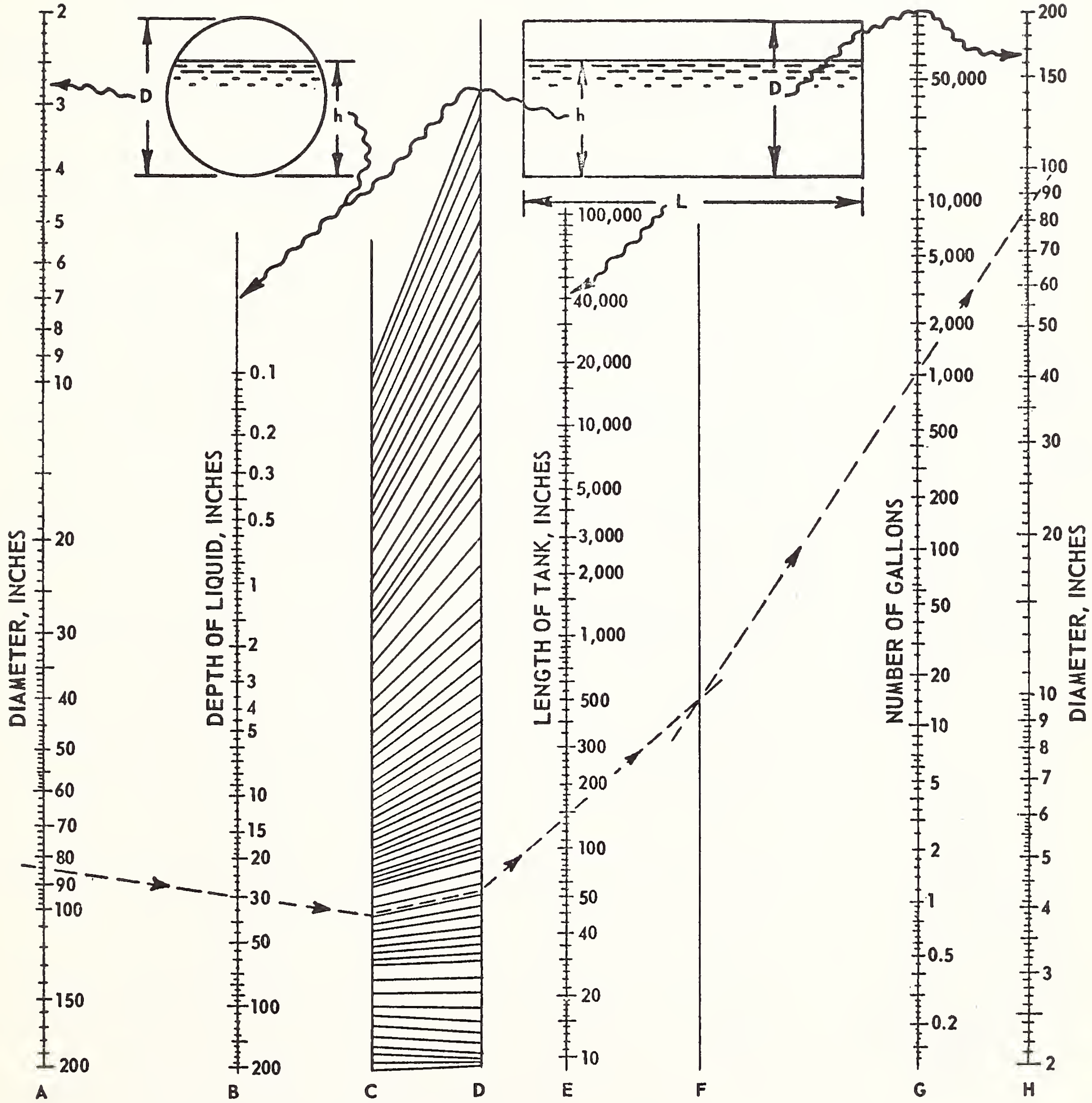
Lineal Feet of Spread for Liquid Asphalt

1.0 Gallon Spread per Square Yard of Finished Road Surface

Gallons of oil	Width of spread, in feet												Gallons of oil
	1	2	3	4	5	6	7	8	9	10	11	12	
	Length of spread, in lineal feet												
5	45	23	15	11	9	8	6	6	5	5	4	4	5
10	90	45	30	23	18	15	13	11	10	9	8	7	10
15	135	68	45	34	27	23	19	17	15	14	12	11	15
20	180	90	60	45	36	30	26	22	20	18	16	15	20
25	225	113	75	56	45	38	32	28	25	23	21	19	25
30	270	135	90	68	54	45	38	34	30	27	25	23	30
35	315	158	105	79	63	53	45	39	35	31	29	26	35
40	360	180	120	90	72	60	51	45	40	36	33	30	40
45	405	203	135	101	81	68	58	50	45	40	37	34	45
50	450	225	150	113	90	75	64	56	50	45	41	38	50
55	495	248	165	124	99	83	70	62	55	50	45	41	55
60	540	270	180	135	108	90	77	67	60	54	49	45	60
65	585	293	195	146	117	98	83	73	65	59	53	49	65
70	630	315	210	158	126	105	90	79	70	63	57	53	70
75	675	338	225	169	130	113	96	84	75	68	62	56	75
80	720	360	240	180	144	120	102	90	80	72	65	60	80
85	765	383	255	191	153	127	109	96	85	77	70	64	85
90	810	405	270	203	162	135	115	101	90	81	74	68	90
95	855	428	285	214	171	143	122	107	95	86	78	71	95
100	900	450	300	225	180	150	128	112	100	90	82	75	100
200	1,800	900	600	450	360	300	256	225	200	180	164	150	200
300	2,700	1,350	900	675	540	450	386	338	300	270	246	225	300
400	3,600	1,800	1,200	900	720	600	514	450	400	360	327	300	400
500	4,500	2,250	1,500	1,125	900	750	643	563	500	450	409	375	500
600	5,400	2,700	1,800	1,350	1,080	900	772	675	600	540	491	450	600
700	6,300	3,150	2,100	1,575	1,260	1,050	900	788	700	630	573	525	700
800	7,200	3,600	2,400	1,800	1,440	1,200	1,029	900	800	720	655	600	800
900	8,100	4,050	2,700	2,025	1,620	1,350	1,157	1,013	900	810	736	675	900
1,000	9,000	4,500	3,000	2,250	1,800	1,500	1,286	1,125	1,000	900	818	750	1,000
1,100	9,900	4,950	3,300	2,475	1,980	1,650	1,415	1,237	1,100	990	910	825	1,100
1,200	10,800	5,400	3,600	2,700	2,160	1,800	1,543	1,350	1,200	1,080	982	900	1,200
1,300	11,700	5,850	3,900	2,925	2,340	1,950	1,671	1,462	1,300	1,170	1,064	975	1,300
1,400	12,600	6,300	4,200	3,150	2,520	2,100	1,800	1,575	1,400	1,260	1,146	1,050	1,400
1,500	13,500	6,750	4,500	3,375	2,700	2,250	1,929	1,688	1,500	1,350	1,228	1,125	1,500

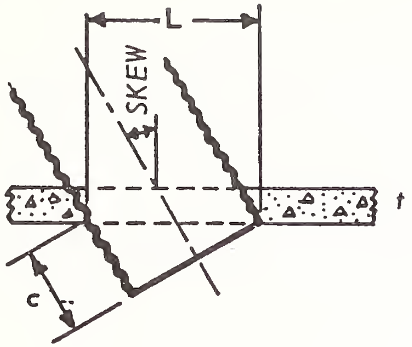
Example: Use 1-gallon application for 1,000-gallon truck. Spread 10 feet wide.
As the table is based on a 1.0-gallon spread per square yard, a 1,000-gallon truck will spread 900 lineal feet 10 feet wide.
For a ½-gallon application, etc., 900 × 2 = 1,800 lineal feet.

CAPACITY CHART FOR CYLINDRICAL TANKS



Example: How many gallons in a tank 84 in. in diameter, the depth of the liquid being 30 in. and the length of the tank being 142 in. ?

Run a straight line through the 84, column A, and the 30 in column B and locate the intersection with column C. By eye follow the radiating guide lines to column D, locating a second point of intersection. From this last intersection run through the 142, column E, and locate the point of intersection in column F. Then from this point run over to the 84, column H, and the intersection in column G will be found to be close to 1,050 gal.



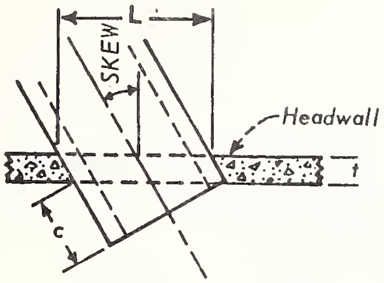
VOL Cu. yds. = $\frac{t}{12}$ X AREA X $\frac{1}{27}$

t = thickness in in.
L = Dia. in ft.
A = Area in sq. ft.
C = Length of cut-off in ft.

CMP

SKEW

DIAMETER		0°	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°
12''	L	1.000	1.004	1.015	1.015	1.064	1.103	1.155	1.221	1.305	1.414	1.556	1.743
	A	0.785	0.789	0.797	0.813	0.836	0.866	0.907	0.959	1.025	1.111	1.222	1.369
	C	0.000	0.087	0.176	0.268	0.364	0.466	0.577	0.700	0.839	1.000	1.192	1.428
18''	L	1.500	1.506	1.523	1.553	1.596	1.655	1.732	1.831	1.958	2.121	2.333	2.615
	A	1.767	1.774	1.794	1.830	1.880	1.950	2.040	2.157	2.307	2.499	2.749	3.081
	C	0.000	0.131	0.264	0.402	0.546	0.699	0.866	1.050	1.259	1.500	1.788	2.142
24''	L	2.000	2.008	2.031	2.071	2.128	2.207	2.309	2.442	2.611	2.828	3.111	3.487
	A	3.142	3.154	3.190	3.253	3.343	3.467	3.627	3.836	4.101	4.442	4.887	5.477
	C	0.000	0.175	0.353	0.536	0.728	0.933	1.155	1.400	1.678	2.000	2.384	2.856
30''	L	2.500	2.510	2.539	2.588	2.660	2.758	2.887	3.052	3.264	3.536	3.889	4.359
	A	4.909	4.928	4.985	5.082	5.223	5.415	5.669	5.993	6.409	6.943	7.636	8.559
	C	0.000	0.219	0.441	0.670	0.910	1.166	1.443	1.751	2.098	2.500	2.980	3.570
36''	L	3.000	3.011	3.046	3.106	3.193	3.310	3.464	3.662	3.916	4.243	4.667	5.230
	A	7.069	7.095	7.177	7.318	7.523	7.799	8.162	8.628	9.227	9.997	10.995	12.323
	C	0.000	0.262	0.529	0.804	1.092	1.399	1.732	2.101	2.517	3.000	3.575	4.284
42''	L	3.500	3.513	3.554	3.623	3.725	3.862	4.041	4.273	4.569	4.950	5.445	6.102
	A	9.621	9.657	9.770	9.962	10.240	10.616	11.108	11.746	12.560	13.607	14.968	16.774
	C	0.000	0.306	0.617	0.938	1.274	1.632	2.021	2.451	2.937	3.500	4.171	4.998
48''	L	4.000	4.015	4.062	4.141	4.257	4.413	4.619	4.883	5.222	5.657	6.223	6.974
	A	12.566	12.613	12.761	13.009	13.374	13.864	14.511	15.340	16.405	17.772	19.550	21.909
	C	0.000	0.350	0.705	1.072	1.456	1.865	2.309	2.801	3.356	4.000	4.767	5.712
54''	L	4.500	4.517	4.569	4.659	4.789	4.965	5.196	5.493	5.874	6.364	7.001	7.845
	A	15.904	15.964	16.148	16.466	16.926	17.548	18.364	19.414	20.760	22.492	24.744	27.727
	C	0.000	0.394	0.793	1.206	1.638	2.098	2.598	3.151	3.776	4.500	5.363	6.426



VOL Cu. yds. = $\frac{t}{12}$ X AREA X $\frac{1}{27}$

t = thickness in in.
L = Dia. in ft.
A = Area in sq. ft.
C = Length of cut-off in ft.

Example – 9" wall
24" RCP 30° skew

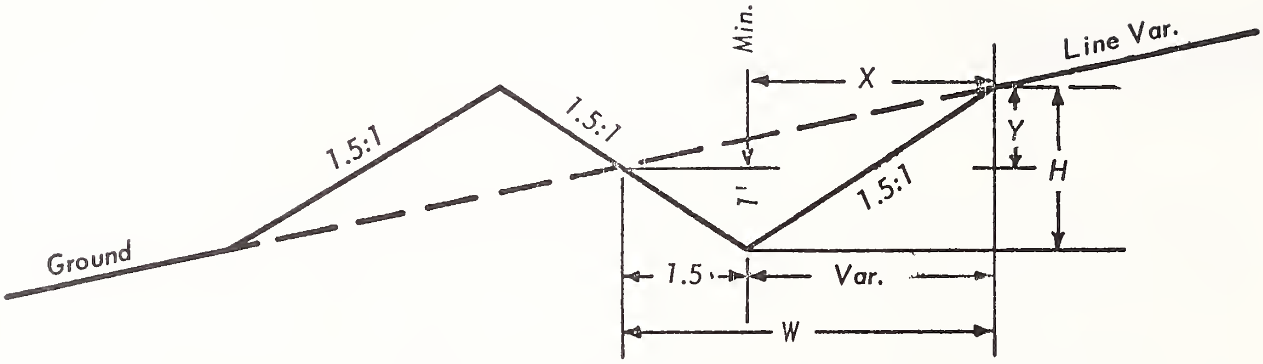
Vol = $\frac{9}{12} \times \frac{(5.298)}{27}$

RCP

SKEW

DIAMETER	0	5	10	15	20	25	30	35	40	45	50	55
12"	L 1.333	1.338	1.354	1.380	1.419	1.471	1.539	1.627	1.740	1.885	2.074	2.324
	A 1.396	1.401	1.418	1.447	1.486	1.540	1.611	1.703	1.822	1.973	2.171	2.433
	C 0.000	0.117	0.235	0.357	0.485	0.622	0.770	0.933	1.119	1.333	1.589	1.904
18"	L 1.875	1.882	1.904	1.941	1.995	2.069	2.165	2.289	2.448	2.652	2.917	3.269
	A 2.761	2.771	2.804	2.858	2.938	3.047	3.188	3.371	3.605	3.905	4.296	4.814
	C 0.000	0.164	0.331	0.502	0.682	0.874	1.083	1.313	1.573	1.875	2.235	2.678
21"	L 2.146	2.154	2.179	2.222	2.284	2.368	2.478	2.620	2.801	3.035	3.339	3.741
	A 3.617	3.630	3.673	3.745	3.850	3.991	4.177	4.416	4.721	5.115	5.628	6.305
	C 0.000	0.188	0.378	0.575	0.781	1.001	1.239	1.503	1.801	2.146	2.557	3.065
24"	L 2.417	2.426	2.454	2.502	2.572	2.667	2.791	2.951	3.155	3.418	3.760	4.214
	A 4.588	4.605	4.658	4.750	4.882	5.063	5.298	5.602	5.989	6.488	7.138	7.999
	C 0.000	0.211	0.426	0.648	0.880	1.127	1.395	1.692	2.028	2.417	2.880	3.452
27"	L 2.688	2.698	2.729	2.783	2.861	2.966	3.104	3.281	3.509	3.801	4.182	4.686
	A 5.675	5.696	5.761	5.875	6.040	6.262	6.553	6.927	7.408	8.025	8.829	9.893
	C 0.000	0.236	0.474	0.720	0.978	1.253	1.552	1.882	2.256	2.688	3.203	3.839
30"	L 2.958	2.969	3.004	3.062	3.148	3.264	3.416	3.611	3.861	4.183	4.602	5.157
	A 6.872	6.898	6.979	7.114	7.313	7.583	7.936	8.389	8.970	9.718	10.691	11.981
	C 0.000	0.259	0.522	0.793	1.077	1.379	1.708	2.071	2.482	2.958	3.525	4.224
33"	L 3.229	3.241	3.279	3.343	3.436	3.563	3.729	3.942	4.215	4.566	5.023	5.630
	A 8.189	8.219	8.316	8.478	8.714	9.036	9.457	9.997	10.689	11.580	12.739	14.278
	C 0.000	0.283	0.569	0.865	1.175	1.506	1.864	2.261	2.709	3.229	3.848	4.611
36"	L 3.521	3.534	3.575	3.645	3.747	3.885	4.066	4.298	4.596	4.979	5.478	6,139
	A 9.737	9.773	9.886	10.080	10.362	10.744	11.244	11.886	12.710	13.769	15.149	16.977
	C 0.000	0.308	0.621	0.943	1.282	1.642	2.033	2.465	2.954	3.521	4.196	5.029
39"	L 3.833	3.848	3.892	3.968	4.079	4.229	4.426	4.679	5.004	5.421	5.963	6.683
	A11.539	11.584	11.716	11.945	12.123	12.731	13.324	14.086	15.064	16.320	17.951	20.119
	C 0.000	.335	.676	1.027	1.395	1.787	2.213	2.684	3.216	3.833	4.568	5.474
42"	L 4.125	4.141	4.189	4.270	4.390	4.551	4.763	5.036	5.385	5.834	6.417	7.192
	A13.364	13.416	13.571	13.834	14.223	14.744	15.431	16.316	17.446	18.901	20.790	23.300
	C 0.000	.361	.727	1.105	1.501	1.924	2.382	2.888	3.461	4.125	4.916	5.891
45"	L 4.396	4.413	4.464	4.551	4.678	4.850	5.076	5.367	5.738	6.217	6.839	7.664
	A15.178	15.236	15.412	15.713	16.151	16.745	17.486	18.530	19.811	21.465	23.612	26.461
	C 0.000	.385	.775	1.178	1.600	2.050	2.538	3.078	3.689	4.396	5.239	6.278
48"	L4.667	4.685	4.739	4.832	4.967	5.149	5.389	5.697	6.092	6.600	7.261	8.137
	A17.107	17.173	17.371	17.711	18.206	18.874	19.753	20.882	22.330	24.192	26.615	29.826
	C 0.000	.408	.823	1.250	1.699	2.176	2.694	3.268	3.916	4.667	5.562	6.665
54"	L 5.250	5.270	5.331	5.435	5.587	5.793	6.062	6.409	6.853	7.425	8.168	9.153
	A21.648	21.730	21.982	22.410	23.037	23.887	24.996	26.426	28.257	30.616	33.680	37.741
	C 0.000	.459	.926	1.407	1.911	2.448	3.031	3.676	4.405	5.250	6.257	7.498
60"	L 5.833	5.855	5.923	6.039	6.207	6.436	6.735	7.121	7.614	8.249	9.074	10.169
	A26.722	26.823	27.135	27.666	28.436	29.465	30.855	32.623	34.882	37.791	41.570	46.587
	C 0.000	.510	1.028	1.563	2.123	2.720	3.368	4.084	4.894	5.833	6.952	8.330
66"	L 6.417	6.442	6.516	6.643	6.829	7.080	7.410	7.834	8.377	9.075	9.983	11.188
	A32.341	32.467	32.840	33.480	34.418	35.683	37.346	39.483	42.219	45.737	50.313	56.386
	C 0.000	.561	1.132	1.719	2.336	2.992	3.705	4.493	5.384	6.417	7.648	9.164
72"	L 7.000	7.027	7.108	7.247	7.449	7.742	8.083	8.545	9.138	9.899	10.890	12.204
	A38.485	38.644	39.078	39.842	40.953	42.465	44.439	46,979	50.239	54.423	59.871	67.095
	C 0.000	.612	1.234	1.876	2.548	3.564	4.041	4.901	5.874	7.000	8.343	9.997

THEORETICAL SURFACE DITCH
END AREAS FOR 2% SLOPE CHANGE

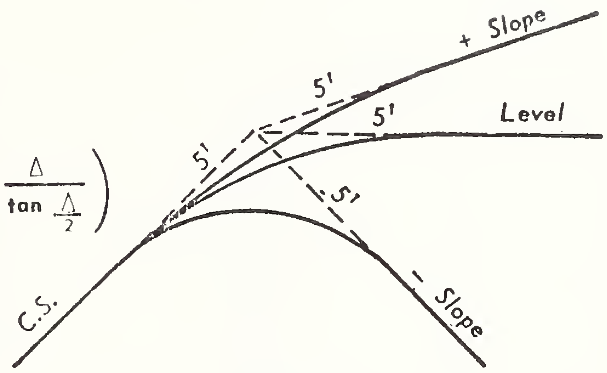


Gr. Sl. %	℄ Cut	W X+1.5	H Y+1.0	Area sq. ft.	Clear Width 2W+4	Gr. Sl. %	℄ Cut	W X+1.5	H Y+1.0	Area sq. ft.	Clear Width 2W+4
0	1.00	3.0	1.00	1.5	10.0	32	1.48	5.8	2.86	4.3	15.6
2	1.03	3.1	1.06	1.6	10.2	34	1.51	6.1	3.07	4.6	16.2
4	1.06	3.2	1.13	1.7	10.4	36	1.54	6.5	3.34	5.0	17.0
6	1.09	3.3	1.20	1.8	10.6	38	1.57	7.0	3.66	5.5	18.0
8	1.12	3.4	1.27	1.9	10.8	40	1.60	7.5	4.00	6.0	19.0
10	1.15	3.5	1.35	2.0	11.0	42	1.63	8.1	4.40	6.6	20.2
12	1.18	3.7	1.44	2.2	11.4	44	1.66	8.8	4.87	7.3	21.6
14	1.21	3.8	1.53	2.3	11.6	46	1.69	9.7	5.46	8.2	23.4
16	1.24	4.0	1.64	2.5	12.0	48	1.72	10.7	6.13	9.2	25.4
18	1.27	4.1	1.74	2.6	12.2	50	1.75	12.0	7.00	10.5	28.0
20	1.30	4.3	1.86	2.8	12.6	52	1.78	13.7	8.12	12.2	31.4
22	1.33	4.5	1.99	3.0	13.0	54	1.81	15.8	9.5	14.3	35.6
24	1.36	4.7	2.13	3.2	13.4	56	1.84	18.8	11.5	17.3	41.6
26	1.39	4.9	2.27	3.4	13.8	58	1.87	23.3	14.5	21.8	50.6
28	1.42	5.2	2.46	3.7	14.4	60	1.90	30.3	19.3	28.8	64.6
30	1.45	5.5	2.65	4.0	15.0						

STANDARD SLOPE ROUNDING
END AREAS FOR 5% SLOPE CHANGE

$$A = R5 - \frac{\pi R^2 \Delta}{360}$$

$$A = \frac{1}{\tan\frac{\Delta}{2}}\left(25 - \frac{25\pi}{360}\ \frac{\Delta}{\tan\frac{\Delta}{2}}\right)$$



Ground Slope −%	End Areas C.S. 1:1	End Areas C.S. 1.5:1	End Areas C.S. 2:1	End Areas C.S. 3:1	Ground Slope +%	End Areas C.S. 1:1	End Areas C.S. 1.5:1	End Areas C.S. 2:1	End Areas C.S. 3:1
− 100	5.37	4.95	4.63	4.22	00	3.13	2.39	1.90	1.33
95	5.32	4.89	4.56	4.14	+ 5	2.95	2.20	1.70	1.13
90	5.27	4.82	4.48	4.05	10	2.77	2.01	1.50	0.92
85	5.21	4.75	4.40	3.96	15	2.58	1.82	1.30	0.71
80	5.15	4.68	4.31	3.87	20	2.39	1.63	1.10	0.50
75	5.08	4.59	4.22	3.76	25	2.21	1.44	0.90	0.29
70	5.00	4.49	4.12	3.66	30	2.02	1.25	0.70	
65	4.92	4.39	4.02	3.54	35	1.84	1.05	0.50	
60	4.83	4.28	3.92	3.41	40	1.66	0.85	0.30	
55	4.74	4.17	3.78	3.28	45	1.49	0.65	0.10	
50	4.63	4.05	3.64	3.14	50	1.33	0.55		
45	4.52	3.91	3.50	2.99	55	1.17	0.35		
40	4.39	3.77	3.35	2.83	60	1.02			
35	4.26	3.63	3.19	2.66	65	0.87			
30	4.13	3.47	3.02	2.49	70	0.72			
25	3.98	3.31	2.85	2.31	75	0.59			
20	3.82	3.14	2.67	2.12	80	0.47			
15	3.66	2.96	2.48	1.93	85	0.37			
10	3.49	2.78	2.29	1.73	90	0.27			
− 5	3.31	2.59	2.10	1.53	+ 95	0.13			

CONVERSION OF MINUTES AND SECONDS TO DECIMAL PARTS OF A DEGREE

Minutes		Seconds		Minutes		Seconds	
0'	0.000000	0"	0.000000	30	0.500000	30	0.008333
1	016667	1	00278	31	516667	31	08611
2	033333	2	00556	32	533333	32	08889
3	050000	3	00833	33	550000	33	09167
4	066667	4	01111	34	566667	34	09444
5	083333	5	01389	35	583333	35	09722
6	100000	6	01667	36	600000	36	10000
7	116667	7	01944	37	616667	37	10278
8	133333	8	02222	38	633333	38	10556
9	150000	9	02500	39	650000	39	10833
10	0.166667	10	0.002778	40	0.666667	40	0.011111
11	183333	11	03056	41	683333	41	11389
12	200000	12	03333	42	700000	42	11667
13	216667	13	03611	43	716667	43	11944
14	233333	14	03889	44	733333	44	12222
15	250000	15	04167	45	750000	45	12500
16	266667	16	04444	46	766667	46	12778
17	283333	17	04722	47	783333	47	13056
18	300000	18	05000	48	800000	48	13333
19	316667	19	05278	49	816667	49	13611
20	0.333333	20	0.005556	50	0.833333	50	0.013889
21	350000	21	05833	51	850000	51	14167
22	366667	22	06111	52	866667	52	14444
23	383333	23	06389	53	883333	53	14722
24	400000	24	06667	54	900000	54	15000
25	416667	25	06944	55	916667	55	15278
26	433333	26	07222	56	933333	56	15556
27	450000	27	07500	57	950000	57	15833
28	466667	28	07778	58	966667	58	16111
29	483333	29	08056	59	983333	59	16389

CONSTRUCTION MANUAL

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INDEX

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Rev. 5-1-73

INDEX

Page

Abbreviations - Surveys 30-1
Acceptance & Final Payment 16-14
Acceptance of Materials 13-3
Accomplishing the Pit Reclamation 21-7
Accuracy - In Surveying 30-19
Adjustment - Claims For 12-9
Administrator - Engineering Division 02-1
Affidavit - Releasing Department of Highways from Reclamation Requirement 21-9
Aggregate - Cold Feed 47-5
Aggregate Production and Surfacing IV-45
Aggregate Proportioning - Batch Plants 47-12
Aggregate Proportioning - Continuous Mix Plants 47-13
Aggregate - Spreading & Compaction 45-9
Aggregate Spreads V-3
Agreed Price - Definition 17-2
Agreed Unit Price 17-11
Agreements - Supplemental 17-4
Air & Water Polution 14-5
Alignment - Concrete Pavement Forms 51-2
Altered Quantities - Definition 17-3
Aluminum Pipe 57-1
Annual Report of Reclamation Plans 21-10
Application - Seal Coat 50-2
Approval of Subcontractors 12-7
Approved - Definition 10-1
Areas of Circular Segments V-1
Asbestos Cement Pipe 62-5
Asphalt Concrete Pavement IV-47
Asphalt Spreads V-4
Asphalt Storage Tanks 47-10
Assembly and Installation - Corrugated Metal Pipe 57-2
Assembly and Installation - Reinforced Concrete Pipe 58-1
Assembly and Installation - Structural Steel Plate Pipe 59-1
Assembly and Installation - Underdrains 60-4
Assignment or Subletting of the Contract 15-1
Authority of the Engineer 12-1
Authorization - Definition 20-2
Authorization - For the Work 20-2
Authorization - For Staking 30-7
Automatic Grade Control - Aggregate Surfacing 45-12
Automatic Grade Control - Plant Mix Surfacing 47-24

Backfilling & Compaction - Culverts 56-10
Backfilling & Compaction - Structural Steel Plate Pipes 59-4
Backfilling & Compaction - Underdrains 60-8
Barbed Wire Fence 64-3
Base Course - Cement Treated IV-46

INDEX

Page

Batch Plant Equipment - Concrete Pavement 51-3
Bench Marks & Leveling 31-10
Bench Marks - Relocation of 30-24C
Belt Scales 45-6
Betterments - Definition 20-2
Bidding - State Law Restricting 15-11
Bin Walls & Retaining Walls - Surveys for 33-1
Blasting of Rock Cuts 41-13
Blasting Record 41-15
Blue Tops - Notes for 30-16
Blue Tops - Staking 31-18
Borrow Areas Adjacent to Rivers, Streams, or Lakes 21-6
Borrow Excavation 41-12
Borrow Pits - Staking 31-17
Bridge Surveys III-35
Buildings - Removal of 40-4
Bump Cutting Hardened Concrete Pavements 51-24
Burlap Embankment Protectors Appendix - 75-A

Capacity Chart for Cylindrical Tanks V-5
Care of Survey Equipment 30-9
Cast Iron Pipe 62-4
Catch Basins - Staking 32-5
Cement Treated Base IV-46
Centerline - Re-establishing 31-1
Certificate of Completion 15-10
Chain Link Fence 64-3
Change Order - Definition 17-3
Change Ordered Work, Extra Work Orders and Force Account Records 17-5
Change Orders 17-6
Changed Condition - Definition 17-1
Changed Conditions 17-4
Changes 11-2
Changes in the Reclamation Plan 21-7
Channel Excavation 41-12
Chapter Numbering & References 01-1
Checking Plans 30-24
Check List - Inspection of Asphalt Pavement 47-29
Chief - Construction Bureau 02-1
Circular Area - Lengths for Unit Radius Appendix - V-2
Circular Segments - Areas of Appendix - V-1
Claim - Definition 10-1
Claims for Adjustment 12-9
Claims - Utility Work 20-3
Clay Pipe 62-3
Cleanup 41-25
Clearance of Right-of-Way IV-40

INDEX

Page

Clearing & Grubbing 40-2
Clearing & Grubbing Stakes 31-14
Cold Feed 47-5
Cold Weather Concreting 51-13
Comfort Stations - Surveys for 33-3
Common Errors on Survey Notes 30-14
Communications I-14
Communications Media in Public Relations 03-1
Compacting - Asphalt Mix 47-26
Compaction - Aggregate Surfacing 45-9
Compaction & Backfilling - Culverts 56-10
Compaction & Density 41-21
Compaction of Roadmix 49-2
Comparison Sheets 16-15
Completion of the Work 12-11
Computer Services - Electronic 30-07
Concrete - Box culverts 32-2
Concrete - Curbs & Gutters 63-1
Concrete - Pavement IV-51
Concrete - Preparation Before Placing 51-1
Concrete Production for Pavements 51-7
Concrete Retaining Walls - Surveys for 33-1
Conditioning Seedbed Surface 44-2
Conditions of Employment 05-6
Conduct of Employees 05-21
Conference - Preconstruction 15-2
Construction Bureau 02-1
Construction - Definition 20-2
Construction Engineering Costs 05-25
Construction - Forms, Records & Reports II-19
Construction Memorandums 04-1
Construction Survey Duties 30-05
Construction Surveys III-30
Construction - Surveys for Bridges III-35
Construction - Surveys for Miscellaneous III-33
Construction - Surveys for Roadways III-31
Construction - Surveys for Small Drainage Facilities III-32
Contract - Assignment or Subletting of 15-1
Contract - Changes II-17
Contract Item - Definition 17-2
Contract - Records 20-9
Contract - Termination of 15-11
Contract - Time 15-7
Contractor and Highway Department Relations II-18
Contractor Equipment, Personnel & Operation 12-6
Contractor - Instruction to 18-1
Contractor - Relations With 03-6
Contractors Responsibilities 13-1
Control of Materials II-13
Control of Runoff Water 75-10
Control of Work II-12
Convenience - Public 14-2

	Page
Conventional Abbreviations	30-1
Conversion Table - Minutes and Seconds to Decimal Parts of a Degree	V-10
Cooperation with Contractor - Surveys	30-24
Corrections to Notes	30-16
Correspondence	04-1
Corrugated Metal Pipe	IV-57
Corrugated Metal Pipe - Drain Pipe	57-5
Corrugated Metal Pipe - Irrigation Pipe	57-6
Corrugated Metal Pipe - Skew Areas of	Appendix-V-6
Corrugated Metal Pipe - Syphon Pipe	57-6
Costs - Engineering	05-25
Costs of Right-of-Way - Definition	20-2
Covers - Manhole	32-5
Cross Section Notes	30-11
Crushing Aggregates	45-3
Culvert Excavation	55-1
Culvert Length Computation	56-7
Culvert Staking Inspection	56-2
Curbs & Gutters	IV-63
Curbs & Gutters - Asphalt	63-4
Curbs & Gutters - Concrete	63-1
Curbs - Surveys for	32-3
Curing - Concrete Pavement	51-20
Cut Sections - Excavation	41-5
Cut to Fill Transitions	41-3
Cylindrical Tanks - Capacity Chart	Appendix-V-5
Daily Plant Mix Report	47-19
Data Transmittal - for Survey Notes	30-18
Default & Termination of the Contract	15-11
Defective Work - Rejection of	12-8
Definitions and Terms - General Terms	II-10
Definitions - Contract Changes	17-1
Definitions - Utilities	20-1
Density	41-21
Design & Operation - Traffic Control	70-3
Detours and Maintenance of Traffic	11-2
Diary - Project	05-18
Dikes	32-2
Director of Highways	02-1
Disposal of Removed Materials	40-4
Disputes	12-9
Ditch Blocks	32-2
Division Construction Section	02-2
Division Materials Section	02-3
Division Office Engineer	02-2
Documentation - Pay Quantities	16-2
Drainage for Gravel Pits & Borrow Areas	21-4
Drop Inlets - Surveys for	32-4
Dryer - Hot Plant	47-5

INDEX

	Page
Dual Administration for Pit Reclamation	21-9
Dust Collector - Hot Plant	47-7
Duties - Scaleman's	45-19
Elements of a Trafficway	70- 5
Eliminated Items	16-4
Eliminated Items - Definition	17-2
Embankment - At Structures	41-20
Embankment Foundation	41-3
Embankment - Over Swampy Areas	41-20
Embankments - Compaction	41-21
Embankments - Earth	41-19
Embankments - Rock	41-18
Employee Conduct	05-21
Engineer and the Law	14-6
Engineer - Authority of	12-1
Engineering Aide	05-4
Engineering Costs	05-25
Engineering Division - Administrator	02-1
Engineers Responsibility	20-3
Equipment - Contractors	12-6
Equipment - Batch Plant	51-3
Equipment - Finishing	51-6
Equipment - Inspection of Concrete Paving	51-3
Equipment - Inspection of Paving	47-21
Equipment - Inspection of Road Mix	49-1
Equipment - Inspection of Seal Coat	50-2
Erosion Control Practice	Appendix - 75-B
Establishment Periods	44-11
Estimate Form 14 - Preparation of	16-11
Estimate Periods	16-13
Estimates - Progress, Final & Semi-Final	16-4
Excavation and Embankment	IV-41
Excavation - Borrow	41-12
Excavation - Channel	41-12
Excavation - Culverts & Minor Structures	IV-55
Excavation - General	41-6
Excavation - Pre-Wetting	41-6
Excavation - Street	41-13
Excavation - Subcut	41-13
Excavation - Unclassified	41-12
Excess Material	41-8
Excess Material - Payment for	16-6
Excess Material Piles	21-7
Expansion Joints - Concrete Pavement	51-18
Expert Witness	14-6
Extra Work - Definition	17-1
Extra Work Order - Definition	17-4
Extra Work Orders	17-13

INDEX

Page

Fabrication - Corrugated Metal Pipe 57-2
Fabrication - Pipe Underdrains 60-4
Fasteners - Corrugated Metal Pipe 57-3
Fasteners - Structural Plate Pipe 59-1
Fasteners - Pipe Underdrains 60-4
Federal Aid Provisions 14-2
Fence - Barbed Wire 64-3
Fence - Chain Link 64-3
Fence - Surveys for 33-1
Fence - Woven Wire 64-3
Fences IV-64
Fertilizer and Mulch 44-6
Fiber Pipe 62-5
Field Laboratory 05-19
Field Office Personnel 05-5
Files - Project 05-8
Fill Settlement Check Elevations 35-26
Filter Material for Underdrains 60-8
Final Estimates 16-4
Final Inspection 12-10
Final Payment 16-14
Finish Grade Stakes 31-18
Finishing & Cleanup 41-25
Finishing & Curing Pneumatically Applied Mortar 74-6
Finishing Concrete Pavement 51-14
Finishing Equipment - Concrete Pavement 51-6
Fish and Game 03-5, 14-5
Fish and Wildlife Habitat - Preservation of 14-10
Flagmen 70-
Flowline - Culverts 56-2
Force Account - Definition 17-1
Force Account Records 17-20
Forms - Form Setting & Alignment Concrete Pavement 51-2
Foundation - Preparation of Roadway 41-2
Freight Rate Increase 17-21
Full Payment of Wages (Anti Kick Back) 18-3

General Correspondence 04-1
General Organization I-02
Government Agencies - Relations With 03-4
Grades and Lines 12-7
Grade Stakes 81-18
Grade Stakes for Culverts & Minor Structures 55-2
Gravel Pits Adjacent to Rivers, Streams, or Lakes 21-6
Grinding - Concrete Pavement 51-24

INDEX

	Page
Guard Rail	33-2
Guidelines for Design & Operation Traffic Control	70-3
Gutters - Surveys for	32-4
Handling & Planting Bare Root Stock	44-9
Handling & Planting Canned or Balled and Burlap Stock	44-10
Haul	42-2
Hauling Plant Mix	47-23
Hazards	40-6
HB 42 & HB 436 Agreements	16-16
Headquarters Organization	02-1
Highway Department and Contractor Relations	II-18
Horizontal Control - Dryland Structure on a Curve	35-11
Horizontal Control - Tangent Dryland Structure	35-4
Horizontal Control - Construction Surveys	30-19
Hot Plant - Cold Feed	47-5
Hot Plant - Scales	47-9
Hot Plant - Screening Unit	47-7
Hot Weather Concreting	51-14
Industrial Accident Insurance Surcharges	17-16
Informing the Public - Traffic Control	70
Inlets - Surveys for	32-4
Inspection & Installation of Culverts	IV-56
Inspection & Records - Cement Treated Base	46-4
Inspection & Records - Concrete Pavement	51-25
Inspection Duties - General	05-7
Inspection - Final	12-10
Inspection - General Control of Work	12-7
Inspection - Hot Plant	47-4
Inspection - Planting	44-8
Inspection - Post Grading	12-9
Inspection - Pre-Completion	12-10
Inspection - Reinforcing Steel	52-1
Inspection - Watering	43-1
Inspectors Check List - Asphalt Pavement	47-29
Inspectors Check List - Hot Plant	47-17
Installation - Pipe Culverts (See Type of Pipe)	Ch. 56 thru 62
Instructions to the Contractor	18-1
Instrumentman	05-2
Insurance - Highway Contracts	14-9
Insurance - On Fencing Contracts	14-9
Insurance - Public Liability & Property Damage	17-16

INDEX

Page

Internal & Interdepartmental Relations 05-19
Irrigation Pipe - Corrugated Metal 57-6
Irrigation Pipe - Reinforced Concrete 58-3
Irrigation Water - Maintenance of 14-6

Job Mix Formula 47-3
Joint Sealers - Concrete Pipe 58-3
Joints - Asphalt Pavement 47-27
Joints - Concrete Pavement 51-17
Joint Venture - Definition 10-1

Keep It Clear & Clean - Traffic Control 70-12
Keyways - Concrete Pavement Joints 51-18

Laboratory - Field 05-19
Labor Compliance 18-2
Labor Compliance - Enforcement 18-3
Labor Compliance Requirements Posting 18-4
Labor Surcharges 17-16
Land & U.S. Survey Monuments 30-21
Landscaping (See Roadside Development) IV-44
Law Restricting Bidding 15-11
Laws to be Observed 14-1
Law - the Engineer and the 14-6
Legal Relations and Responsibilities II-14
Length of Circular Arcs for Unit Radius Appendix - V-2
Leveling & Bench Marks 31-10
Limitation of Operations 15-7
Lines & Grades 12-7
Liquidated Damages 15-10
Locally Available Materials 41-8
Location of Crushing Plants and Hot Plants 21-5
Location of Gravel Pits & Borrow Areas 21-4
Location of Haul Roads for Gravel Pits & Borrow Areas 21-4

Maintenance - of Completed Base Surface 35-13
Maintenance - of Irrigation Water 14-6
Maintenance - of the Roadbed 41-27
Maintenance - of Traffic 11-2
Major Item - Definition 17-3
Management I-05
Management of Engineering Control Surveys 35-29
Manholes - Staking of 32-5
Manually Operated Screed - Plant Mix 47-25
Markers & Monuments IV-69
Mass Diagram 42-2
Materials - Acceptance or Rejection 13-3
Materials - Concrete Pavement 51-8
Materials - Control of II-13
Materials - Curb & Gutter 63-1
Materials - Disposal of Unsuitable 40-4

INDEX

Page

Materials - Fences 64-1
Materials - Found in the Work 11-4
Materials - Locally Available 13-2
Materials - Markers & Monuments 69-1
Materials - Metal Pipe 57-1
Materials on Hand - Payment for 16-2
Materials - Pipe Underdrains 60-4
Materials - R.C.P. 58-1
Materials - Reinforcing Steel 52-1
Materials - Seal Coat 50-1
Materials Section - Division 02-3
Materials - Structural Plate Pipe 59-1
Mats and Mesh Covers 75-8
Measurement & Payment II-16
Measurement - Bedding Material 55-4
Measurement - Culvert Excavation 55-4
Measurement - Filter Material for Underdrains 60-5
Measurement - Remove & Relay Culverts 61-2
Metal Pipe 57-1
Minimum Wage & Hour Requirements 18-2
Minor Item - Definition 17-3
Minor Structures - Excavation for 55-1
Minor Work-Assessment for 15-9
Miscellaneous Rigid Pipe IV-62
Mix Design - Asphalt Pavement 47-3
Mix Proportioning - Asphalt Pavement 47-12
Mixing - Cement Treated Base 46-2
Mixing - Concrete Pavement 51-12
Mixing Limitations - Concrete Pavement 51-13
Mixing - Road Mixed Asphalt 49-2
Money Formula 17-9
Monuments - Right-of-Way 33-3
Mortar - Pneumatically Applied IV-74
Mulch 44-6
Mulch for Temporary Erosion Control 75-5

Night Limitations - Concrete Pavement 51-14
Non - Descrimination 18-3
Non - Participating Items 16-7
Non - Reinforced Concrete Pipe 62-1
Notes for Electronic Computation 30-10

Obstructions - Removal of 40-4
Office Engineer - Division 02-2
Opening to Traffic - Concrete Pavement 51-25
Operation - Contractor's 12-6
Operation - Traffic Control 70-3
Optimum Moisture - Rule of Thumb 41-25
Order of the Engineer - Definition 10-1
Organization Chart 02-01
Organization General I-02

Page

Overbreak - Definition 10-1
Overburden in Gravel Pits & Borrow Areas 21-5
Overhaul & Haul IV-42
Overhead Costs - Definition 20-2
Overhead - Definition 10-1
Overrun of Contract Time 15-8

Parallel Spiral Curves 31-11
Pavement - Asphalt IV-47
Pavement - Concrete IV-51
Pavement - Protecting New Concrete 51-24
Paving Operations & Inspection - Asphalt Pavement 47-20
Payment - Claims for Adjustment 12-9
Payment for Excess Material 16-3
Payment for Materials on Hand 16-2
Payment for Traffic Control 70-
Pay Quantity Documentation 16-2
Personnel 05-1
Personnel - Contractor's 12-6
Pipe Culverts - Surveys 32-1
Pipe Underdrains - Construction 60-4
Pit Release 21-7
Pits - Dual Administration of Department of Highways and Department of State Lands 21-9
Placing & Finishing - Cement Treated Base 46-3
Placing & Finishing - Concrete Pavement 51-14
Plans - Checking Before Survey 30-24
Planning - Traffic Control 70-2
Planting 44-7
Planting - Inspection 44-8
Planting - Notes 44-13
Plant Inspection - Asphalt Pavement 47-4
Plant Inspection - Concrete 51-11
Plant Mix - Daily Report 47-19
Plastic Pipe 62-5
Pneumatically Applied Mortar IV-74
Pollution 14-5, 47-7
Portland Cement Concrete Pavement IV-51
Post Grading Inspection of Interstate Projects 12-9
Posting of Labor Compliance Requirements 18-4
Precision Accuracy & Tolerance - Surveys 30-19
Pre-Completion Inspection 12-10
Preconstruction Conference 15-2
Preliminary Engineering - Definition 20-2
Premium on Bond 17-16
Preparation of Roadway Foundation 41-2
Preparations - Placing Concrete Pavement 51-1
Preservation of Property 14-3

INDEX

Page

Presplitting 41-14
Pre-wetting Excavation Areas 41-6
Prior Approval - Definition 17-4
Prior Approval of Change Orders 17-5
Prior Approval of Utility Work Orders 20-6
Production Cost - Definition 10-2
Progress Billing for Utility Relocation Work 20-5
Progress Estimates 16-4
Progress of the Work II-15
Progress Reports 19-13
Project Diary 05-18
Project Files 05-8
Project Management I-05
Project Manager 05-1
Project Offices & Field Laboratory 05-19
Project Records - Retention of 19-16
Property Damage Insurance 17-16
Property Owners - Relations With 03-3
Prosecution of the Work II-15
Protecting Concrete Pavement 51-24
Protection of Property - Legal 14-3
Protection of Property - Clearing Land 40-2
Pruning 44-10
Public Convenience & Safety 14-2
Public Liability Insurance 17-16
Public Records 03-02
Public Relations I-03
Pugmill Mixer - Asphalt Plant 47-11
Purpose of This Manual 01-1

Quantity Documentation 05-12, 16-2

Radio 04-5
Railroad - Bills for Flagging 20-5
Railroad Companies - Relations With 03-6
Railroad - Review of Flagging Hours 20-10
Rate Increases - Freight 17-21
Ratio of Accuracy - For Linear & Angular Error 30-20
Reclamation of Gravel Pits and Borrow Areas II-21
Reclamation Plans - Review of 21-3
Reclamation Plans - Changes to 21-7
Reclamation Plans - for Pits Adjacent to Rivers 21-6
Records and Documentation - Culverts General 56-13
Records and Documentation - CMP 57-8
Records and Documentation - RCP 58-4
Records and Documentation - Remove and Relay Culverts 61-05
Records and Documentation - SSPP 59-5

INDEX

	Page
Records and Documentation - Underdrains	60-10
Re-establishing Centerline	31-1
Reinforced Concrete Pipe - Drain Pipe	58-3
Reinforced Concrete Pipe - Irrigation and Syphon Pipe	58-3
Reinforced Concrete Pipe - Skew Areas of	V-7
Reinforcing Steel	IV-52
Rejection of Defective or Unauthorized Work	12-8
Rejection of Material	13-3
Reject Piles	21-7
Relations - Communications Media	03-1
Relations - Contractor	03-6, II-18
Relations - General Public	03-1
Relations - Governmental Agencies	03-4
Relations - Interdepartmental & Internal	05-19
Relations - Legal	II-14
Relations - Property Owners	03-3
Relations - Public	I-03
Relations - Utility & Railroad Companies	03-6
Relocation of U.S.C. & G.S. Bench Marks	30-24C
Removal - Structures and Obstructions	40-4
Remove & Relay Culverts	IV-61
Removing Forms - Concrete Pavement	51-20
Removing Topsoil	41-2
Responsibilities - Contractors	13-1
Responsibilities - Engineers	20-3
Rest Area - Surveys	33-3
Resumption of the Work	15-5
Retaining Walls - Surveys for	33-1
Retention of Project Records	19-16
Review of Reclamation Plans	21-3
Revised Culvert List	56-1
Revisions and Updating - Construction Manual	01-2
Right of Access - Definition	10-2
Right-of-Way - Clearance of	IV-40
Right-of-Way Cost - Definition	20-2
Right-of-Way Monuments	33-3
Right-of-Way Staking	31-14
Rip Rap Sources	21-8
Road Approaches - Notes for	30-16
Roadbed - Maintenance of	41-27
Roadbed Preparation - Asphalt Pavement	47-2
Roadbed Preparation - Cement Treated Base	46-2
Roadbed Preparation - Concrete Pavement	51-1
Roadbed Preparation - Road Mix	49-1
Roadbed Prepatation - Seal Coat	50-1
Road Mixed Asphalt Surfacing	IV-49

INDEX

Page

Roadside Development IV-44
Roadway - Preparation of Foundation 41-2
Roadway Prism - Definition 10-2
Roadway Surface Preparation for Sealcoat 50-1
Rock Cuts - Blasting of 41-13
Rock Embankment 41-18
Rock Quarries & Rip Rap Sources 21-8
Rodman 05-3
Rolling - Aggregate 45-9
Rolling - Cement Treated Base 46-3
Rolling - Compacting Asphalt Mix 47-26
Rolling Seal Coat 50-4
Run-off Diversion 75-10
Rule of Thumb for Optimum Moisture 41-25

Safety 30-6
Safety & Convenience of the Public 14-2
Salvage - Utilities 20-9
Salvage Value - Definition 20-2
Sample Cross-Section Notes 30-18
Sawing - Concrete Pavement 51-18
Scale Inspection 45-7
Scaleman's Duties 45-19
Scales - Batch Plant 47-9
Scales - Belt 45-6
Scales - Hot Plant 47-12
Scope of Work II-11
Screeding Concrete Pavement 51-15
Screening Aggregate 45-3
Screening Unit - Hot Plant 47-7
Seal Coat IV-50
Sealing Concrete Pavement Joints 51-19
Seasonal Suspension of Work 15-6
Sediment Traps 75-14
Seedbed Surface - Conditioning of 44-2
Seeding 44-3
Seeding Notes 44-13
Semi-Final Estimates 16-4
Serrated Slopes 41-10
Sewers 56-12
Shaping Concrete Pavement 51-15
Shoulder - Definition 10-2
Shrinkage & Swell 30-12
Sidewalks - Surveys for 32-4
Signatures on Claims & Correspondence 04-3
Simple Curves 31-3
Skew Areas of CMP V-6
Skew Areas of RCP V-7
Slab Inspector - Concrete Pavement 51-26
Slip Formed Concrete Pavement 51-21

	Page
Slope Drains	75-12
Slopes - Excavation & Embankment Areas	41-9
Slopes - Gravel Pits and Borrow Areas	21-6
Slope Staking	31-15
Social Security Surcharges	17-16
Sodding	75-10
Speed Zones	70-12
Spiral Transition Curves	31-10
Spreading - Aggregates	45-9
Spreading - Asphalt Pavement	47-24
Spreading - Concrete Pavement	51-15
Spreading - Road Mix	49-2
Spreading & Rolling - Seal Coat	50-2
Spreads - Aggregate	V-3
Spreads - Asphalt	V-4
Staking Authorization	30-7
Staking Borrow Pits	31-17
Staking Center Line	31-2
Staking Inspection - Culverts	56-2
Staking Right-of-Way	31-14
Standard Shrink & Swell Factors	30-13
State - Definition	20-2
Start of Work	15-1
Stockpass	59-1
Stockpiling - Aggregates	45-5
Storage of Plants	44-8
Storage Tanks - Asphalt	47-10
Street Excavation	41-13
Structural Plate Pipe Culverts and Stockpasses	IV-59
Structure Settlement Check Elevations	35-27
Structures Involving Railroads	35-29
Structures - Removal of	40-4
Subcontractor - Definition	10-2
Subcontractor - Approval of	12-7
Subcut Excavation	41-13
Subgrades in Cut Sections	41-5
Subletting	15-1
Substantial Compliance - Definition	10-2
Supervisor - Division Construction Section	02-2
Supplemental Agreement - Definition	17-3
Supplemental Agreements	17-4
Surcharges, Premiums & Insurance Costs	17-15
Surface Protection of Exposed Soils	75-5
Surface Smoothness - Asphalt Pavement	47-27
Surface Test - Concrete Pavement	51-20
Survey Equipment - Care of	30-9
Survey Monuments	30-21
Survey Notes - General	30-10

Page

Suspend Orders - Issuance of 15-7
Suspension of the Work 15-5
Swampy Areas - Embankment Over 41-20
Symbols and Abbreviations - on Note 30-1
Syphon Pipe - CMP 57-6
Syphon Pipe - RCP 58-3

Table of Construction Forms and Reports 19-2
Tamping and Screeding Concrete Pavement 51-15
Telephone and Teletype 04-4
Temperature Correction for Steel Tape 30-20
Temporary Erosion & Sediment Control IV-75
Temporary Erosion & Sediment Control - Sample Plan Appendix - 75-C
Termination - Contract 15-11
Theoretical Surface Ditch End Areas for 2% Slope Change V-8
Tiebars - Concrete Pavement Joints 51-18
Tolerance - Definition 10-2
Tolerance - In Pavement Thickness 51-25
Tolerance - In Surveying 30-19
Topsoil 41-2, 44-1
Topsoil in Gravel Pits & Borrow Areas 21-5
Traffic Control IV-70
Traffic Control - During Paving 47-20
Traffic Control - During Seal Coating 50-4
Traffic Control - Informing the Public 70-12
Traffic Control - Payment 70-13
Traffic Control - Planning 70-2
Traffic Control - Survey for 33-2
Trafficway Elements of 70-5
Transitions - Cut to Fill 41-3
Trapping of Sediment 75-14
Triangulation 35-11
Types of Excavation 41-12

Unauthorized Work - Rejection of 12-8
Unclassified Excavation 41-12
Underdrain Pipes IV-60
Unemployment Compensation Surcharges 17-16
Unit Price 17-2
Unreclaimed Pits 21-8
Unsuitable Material - Disposal of 40-4
Unsuitable Materials 41-7
Unusual Situations - Survey Notes 30-17
Utah - Report on Burlap Embankment Protectors Appendix - 75-A
Utilities - General Information II-20

	Page
Utilities - Surveys for	33-2
Utility Claims	20-3
Utility Companies - Relations With	03-6
Utility - Definition	20-1
Utility - Relocation	20-6
Utility Work Orders	20-6
Vegetation in Gravel Pits and Borrow Areas	21-6
Vertical Controls for Bridges	35-25
Vertical Controls for Construction Surveys	30-19
Wage & Hour Requirements - Minimum	18-2
Wages - Full Payment of	18-3
Waste Material from Gravel Pits & Borrow Areas	21-6
Watering	IV-43
Water Pollution	14-5
Wildlife - Preservation of Habitat	14-10
Witness - Expert	14-6
Work - Authorization for	20-2
Work - Completion of	12-11
Work - Control of	II-12
Work - Definition	10-3
Working Conditions	05-6
Work Orders - Contract Changes	17-5
Work Orders - Utility Work	20-6
Work Resumption	15-5
Work - Start of	15-1
Work Suspension	15-5
Woven Wire Fence	64-3
Written Orders To & From the Contractor	12-2